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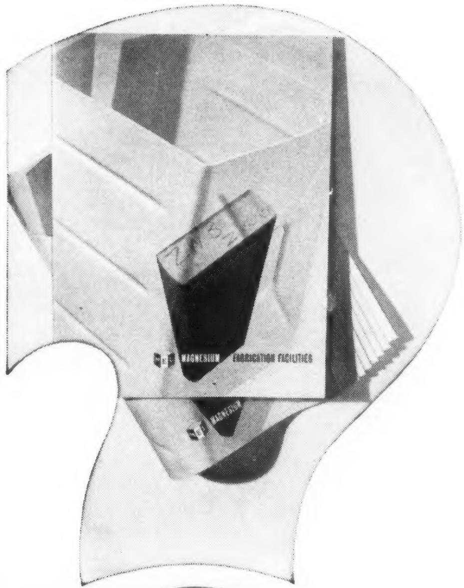

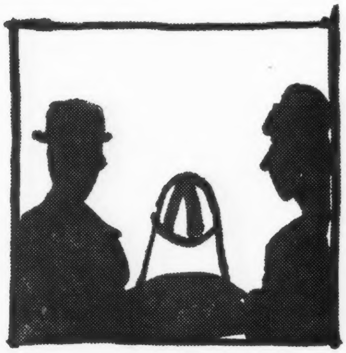

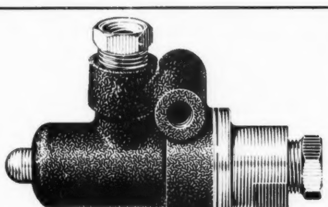

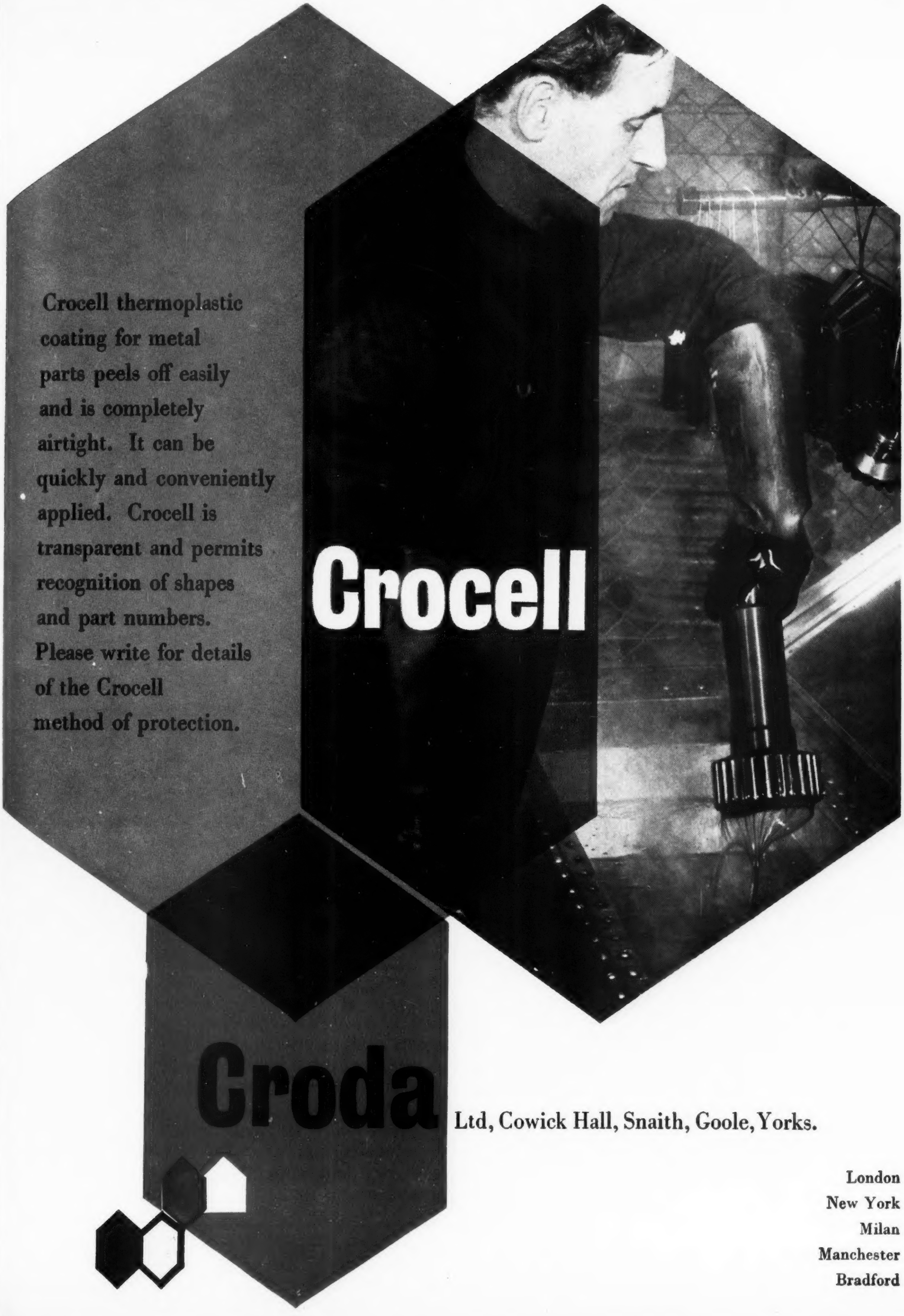
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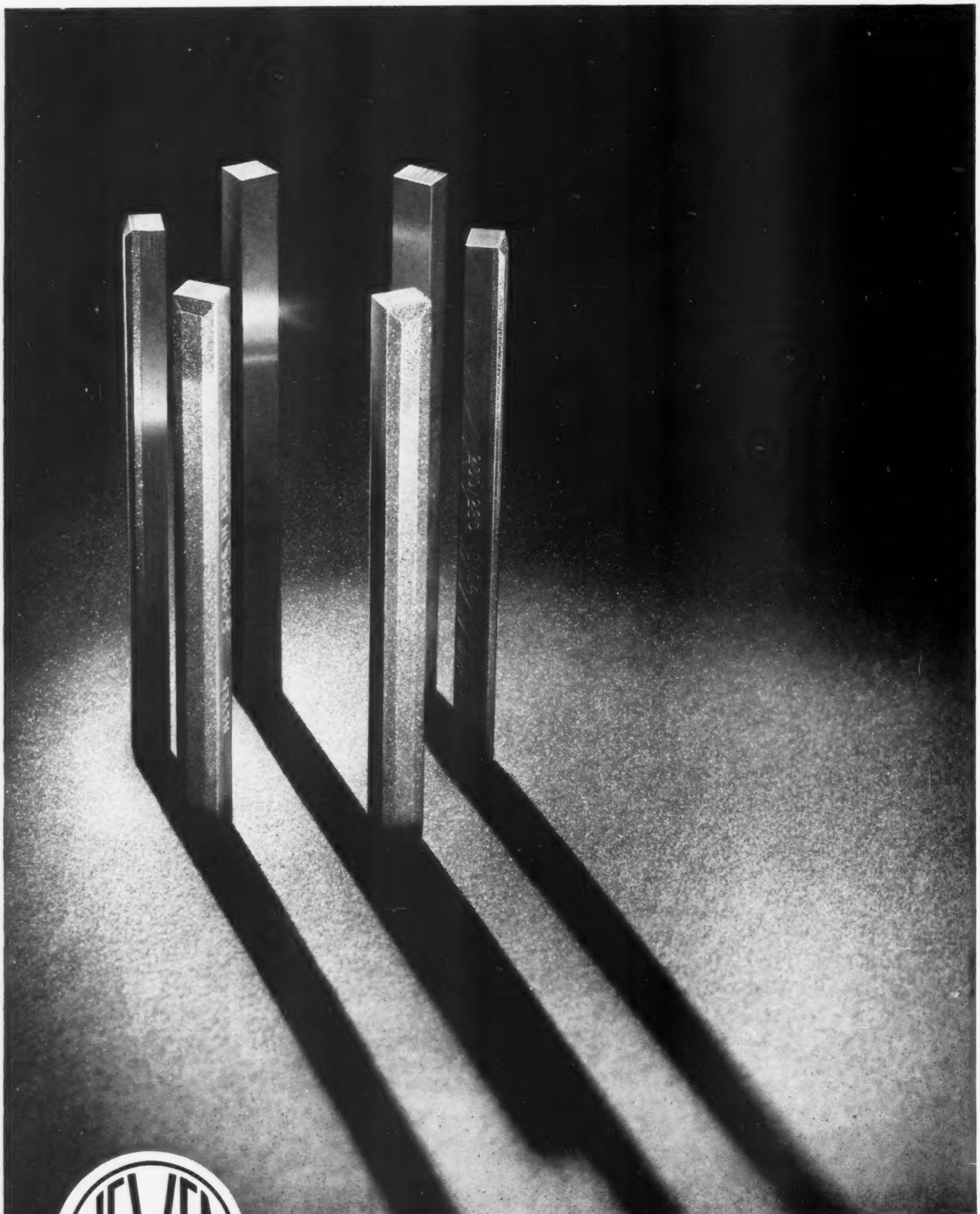

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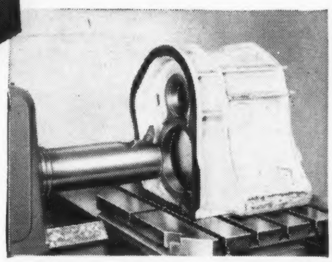

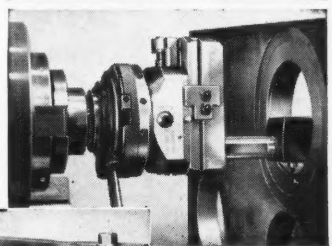

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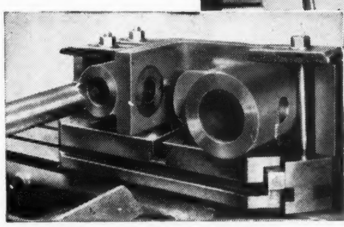

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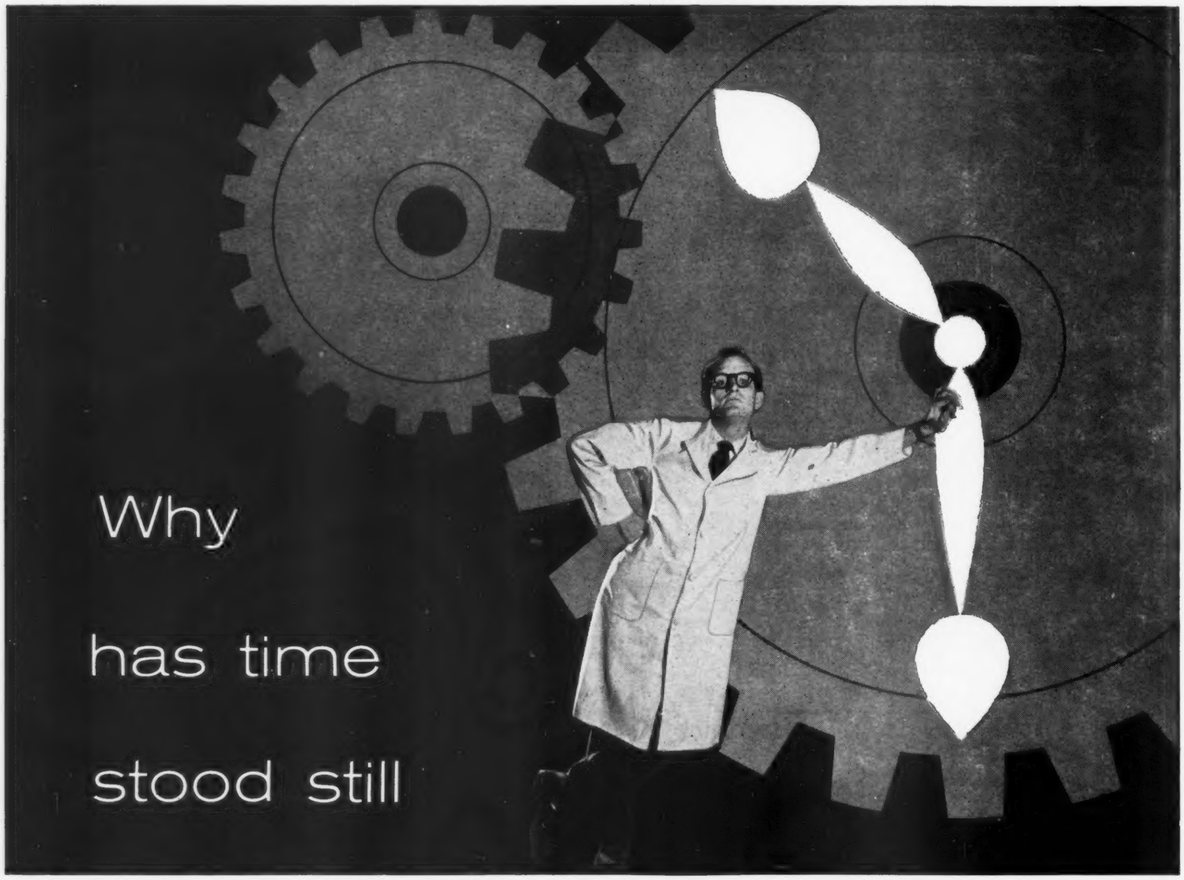

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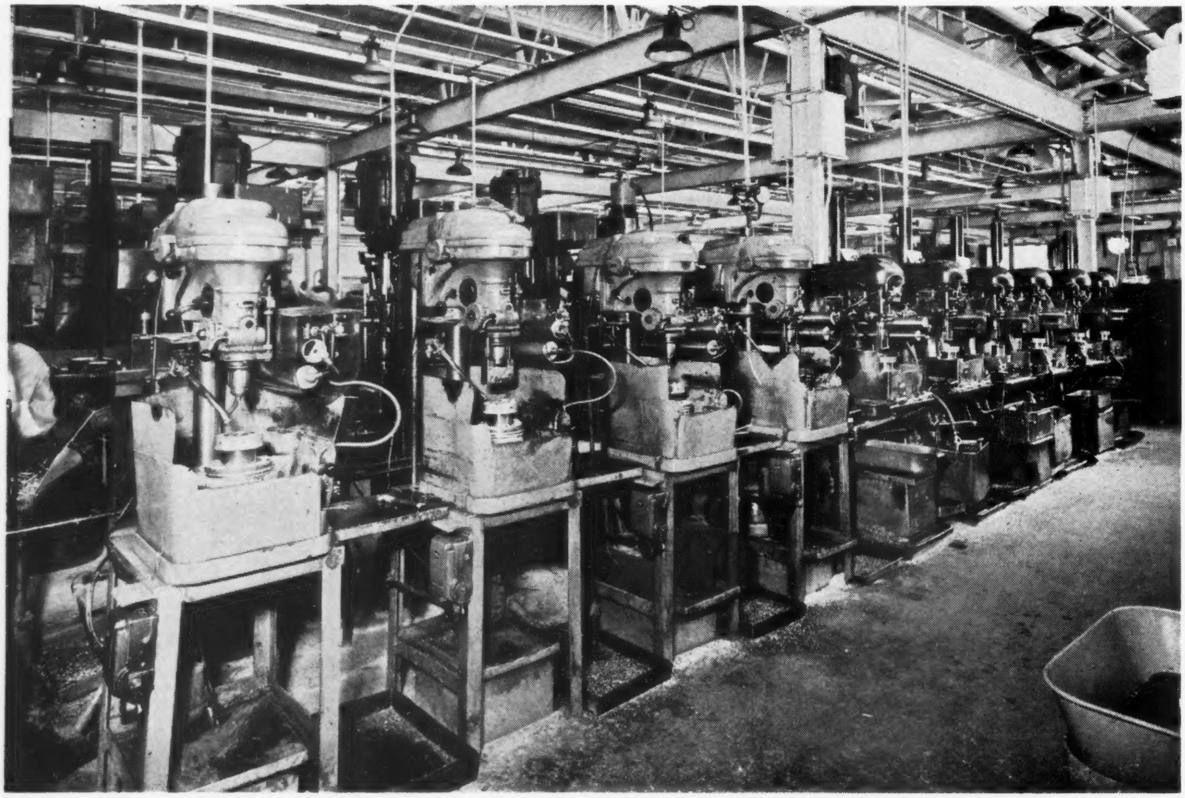

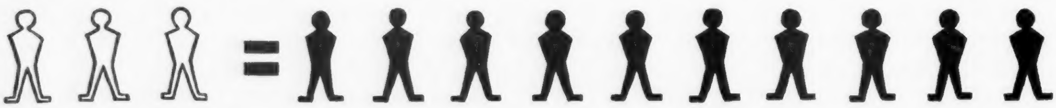

"Automatic Production - Change and Control"

Publication of the Papers presented at the Harrogate Conference in July last is concluded in this issue of the Journal. A separate publication, containing a full Report of the Conference, including the Discussion Group Reports presented to the Third Plenary Session, is in course of printing, and copies will shortly be available, on order, at the special price to members of the Institution and those non-members who attended the Conference, of 20s. per copy, plus 1s. postage and packing charge. (The published price will be 30s., plus 1s. postage and packing charge.)

The Report, which will be a complementary volume to "The Automatic Factory — What Does it Mean?", will be produced in the same size and format, with board covers, and may be ordered from:

THE PUBLICATIONS DEPARTMENT,
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THE CONTROL OF QUALITY IN AUTOMATIC PRODUCTION

by JOHN LOXHAM, C.G.I.A., M.I.Mech.E., M.I.Prod.E.

After completing an apprenticeship with Messrs. W. L. Holland and Sons, Preston, Mr. Loxham acquired varied experience with a number of engineering firms as Assistant Foreman and Foreman. He later spent some time with Leyland Motors Ltd., as a jig and tool draughtsman.

In 1930, he became Chief Jig and Tool Draughtsman and later Assistant Production Manager at Platt Bros. Ltd., Oldham, and two years later was appointed Responsible Lecturer in Production Engineering and later Head of the Engineering Production Department at the Northampton Polytechnic, London, where he established the first National Certificate Course in Production Engineering, and set up the first Technical College Machine Tool Laboratory. By analysing measurements taken on parts made in this Laboratory, Mr. Loxham discovered that great practical benefit could result from the use of measurements to control production processes in industry, and accordingly decided to return to industry with the object of developing a range of British fine measuring instruments for use in engineering workshops, and also of experimenting in the techniques of management and labour relations.

In 1939, he became Manager, and was later appointed to his present position of Managing Director, of The Sigma Instrument Company Ltd., Letchworth, where he has had considerable success in achieving his aims.

Mr. Loxham has travelled widely and has lectured on subjects associated with technical education and the control of quality in engineering production in many parts of the world. In 1946, he was awarded the Sir Joseph Whitworth Prize by the Institution of Mechanical Engineers for his Paper on "An Experiment in the Use of a Standard Limit System", and the City and Guilds of London have recently conferred on him the Insignia Award in Technology in the field of Mechanical Engineering.

Among his many activities, Mr. Loxham is a Member of Council of the Scientific Instrument Manufacturers' Association and The Gauge and Toolmakers' Association; a Governor of the National College of Horology and Instrument Technology; a Governor and Chairman of the Engineering Advisory Committee for the North Hertfordshire Technical College; a member of the City and Guilds Advisory Committee in Instrument Making and Maintenance; and Chairman of the B.S.I. Committee on Limits and Fits, and a member of several other B.S.I. and I.S.O. Committees.

AUTOMATIC production as it will be considered in this Paper, consists of either continuous, self-repeating or push button impulsed fully automatic manufacturing cycles. By elimination of human judgment or influence, the process becomes one which is operating under the influence of natural laws. These natural laws being part of the fundamental laws of nature are 100% reliable. They never fail to conform to a fixed, and in some instances, a known pattern of behaviour. Instances may occur when it appears that the fixed and known pattern of behaviour is not being followed, but the only correct conclusion to draw from such evidence is that our knowledge of the law governing that particular pattern is inadequate. With such a set of unique circumstances as a basis, the problem of controlling the quality of the parts produced becomes a fascinating and, from a commercial standpoint, a very well worthwhile human endeavour.

A detailed study of current practice in fully automatic production processes shows that more than 80% can be classified in one or other of the following two groups :-

FURTHER CHARACTERISTICS OF GROUPS A AND B

	GROUP A *Characteristics of Stable Manufacturing Processes*	GROUP B *Characteristics of Unstable Manufacturing Processes*
Type of machine	Single and multi-spindle auto-lathes, auto-single and multi-station milling, broaching and boring machines, blanking and forming presses, moulding machines, precision forging machines, die casting machines, etc.	Cylindrical, external and internal grinding machines, centreless and surface grinders.
Type of cutting or forming tool	Tungsten carbide, diamond, ceramic, high speed steel. High carbon and alloy punch and die steels.	Wide range of grinding wheels.
No. of dimensions to be controlled	Relatively large number, usually three to 12.	Relatively small number, in most cases one ; occasionally two to five.
Rate of change of size with time	Very slow. Tools reset at intervals of four to eight hours.	Very rapid. Machine may require re-setting every three to 15 mins.
Adjustment of machine for control of size	Complex and lengthy operation. Tool or die may require regrinding.	Very easy. Usually small angular rotation of feed wheel or depression of feed control button.
Method of control	By convenient and accurate measurement enabling machine setter to observe degree of stability of manufacturing process, and also the size of all important dimensions on the part in relation to the tolerance boundaries.	Fully automatic control of size by using feedback from measuring device to make machine self-adjusting for size control.
Standard of Accuracy	Most existing tolerances can be divided by two and in some cases divided by four.	Most existing tolerances can be divided by two and in some cases by five.

GROUP A

Production processes where the drift in size in relation to time is very slow and, in consequence, the process can be considered stable from the standpoint of dimensional change.

GROUP B

Production processes where the drift in size in relation to time is rapid and, in consequence, the process must be considered as unstable from the standpoint of dimensional change.

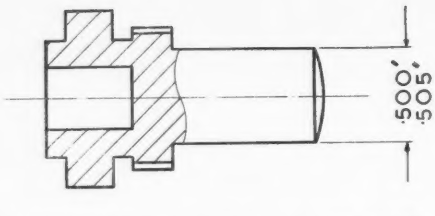
Further characteristics in the above two groups are given in the Table above.

Control of manufacturing process.
Group A. Stable manufacturing processes

The majority of automatic manufacturing processes in use in engineering workshops use cutting or forming tools made from material which is intended to withstand, for long periods and without serious deformation, the abrasive action imposed by the process. If, as is customary, it is possible to add very fine tolerances to the arrangements whereby spindles rotate about fixed axes, slides move along straight lines parallel or at fixed angles to the axes about which the spindles are rotating, a stable manufacturing process has been created.

The above conditions are possible of attainment and from a commercial standpoint they are very desirable. One of the purposes of the present Paper is to describe a technique which indicates to the person in control of the process the extent to which these attainable and highly desirable conditions are satisfied.

The diagram in **Fig. 1** illustrates a simple part on which the author carried out early and very simple experiments. The chart shows the measured size of 15 parts produced consecutively on a 5-spindle automatic lathe. Prior to measurement, the 15 parts had all been inspected by a limited fixed anvil type caliper gauge and all parts were declared inside tolerance and the setting of the machine as completely satisfactory. Individual measurement revealed that the spread of size in this small group of parts was excessive, and that this was primarily due to three of the parts being substantially smaller than the remainder of the group. Further investigation showed that the three small parts had all been produced on spindle No. 4 of the 5-spindle machine, and that this condition had probably existed for about two years. Four hours' maintenance service to the machine completely corrected the fault.



PART PRODUCED ON FIVE SPINDLE AUTOMATIC LATHE

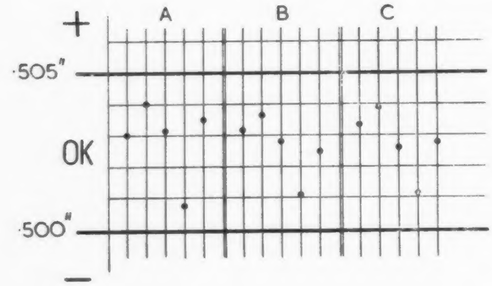


CHART SHOWING RESULT OF INSPECTING ONE DIMENSION ON THREE GROUPS OF FIVE PARTS PRODUCED CONSECUTIVELY ON FIVE SPINDLE AUTOMATIC LATHE.

Fig. 1.

In practice the problem is more complex than as illustrated by Fig. 1, because parts produced on automatic lathes and similar automatic equipment must usually satisfy a predetermined standard of dimensional accuracy on several dimensions simultaneously. An example taken from current practice which illustrates this more typical condition is illustrated in Fig. 2.

In the part illustrated, the specification demands that 10 dimensions be produced simultaneously to a clearly stated predetermined tolerance. In this experiment, 15 parts were produced consecutively on a 5-spindle automatic lathe and carefully measured on the 10 specified dimensions. The measured sizes were plotted as shown on the chart (Fig. 2). About 90 minutes were spent measuring and plotting the 15 sizes. The analysis of the results took only one minute and revealed the following important technical information :-

1. Dimensions No. 3 and 4 are seriously unstable ; they follow a similar pattern, and the production equipment is in urgent need of adjustment.
2. Dimensions No. 1, 5 and 8 are fairly satisfactory, but are not considered sufficiently stable for an ideal production process and some small improvement is desirable.
3. Dimensions No. 2, 6, 7, 9 and 10 are very stable, but dimensions No. 2 and 6 are near the boundaries of the tolerance and further investigation is necessary to discover the direction in which the size will drift as production proceeds.

An examination of the diagram and a knowledge of the tooling on the machine shows that the drift of dimension No. 2 will be towards the centre of the tolerance and no tool adjustment is necessary. The drift of dimension No. 6 will be towards the limit of minimum size and this tool must, therefore, be adjusted either immediately or in the very near future. The diagram also shows that dimensions No. 3 and No. 4 are two adjacent diameters and on examining the tooling on the machine producing the part, it was found that both diameters were produced by the same form tool. The instability of these two dimensions was, therefore, due to the lack of consistency in the movement of the slide carrying this form tool. Further investigation proved this diagnosis to be true and about 30 minutes' maintenance on the machine corrected the fault.

The above two simple examples show the value of investigating the stability of processes when for efficient production the process is of a character which should remain stable for long periods.

Many attempts have been made by investigators operating in different countries to provide a system which would supply the above type of data in a convenient form and at a low cost, but up to the present no system has been generally adopted because of excessive cost of obtaining this clearly useful information. In an age when mechanisation is reducing the cost of many operations from office accountancy to the manufacture of supersonic aircraft, it is logical to consider whether mechanisation can assist in reducing the cost of providing important dimensional information concerning the manufacture of mass produced parts, and present this information promptly and in a manner which is easily understood by the persons requiring the information. The next section of this Paper describes a system designed to satisfy this need.

Conditions to be satisfied for ideal control

Consider the control of the manufacturing process used to produce the part illustrated in Fig. 2:
Machine : 5-spindle automatic lathe.
Part : As illustrated in Fig. 2.
No. of dimensions to be controlled : 10.

The ideal inspection unit should satisfy the following conditions :-

1. All dimensions must be inspected simultaneously.
2. Tolerance boundaries for all inspected dimensions must be clearly shown.
3. The equipment must show clearly and accurately the measured size of each dimension inspected and the disposition of this size in relation to the particular tolerance boundary.
4. The equipment must indicate the direction in which size of each measured dimension can be expected to drift as production proceeds.
5. The equipment must indicate promptly, clearly and accurately the dimensional stability of the manufacturing process associated with each dimension inspected.

6. The equipment must be of a type which can be set to a high standard of accuracy by means of a relatively inexpensive setting master.
7. Errors due to gauge makers' tolerance and gauge wear or their equivalent, must be reduced to a degree which makes errors from these causes of no commercial significance.
8. The equipment must be suitable for percentage inspection and of a type which can be used by the machine setter, the patrol inspector or any other authorised person. If required, it must also be suitable for final 100% inspection in special circumstances.
9. Standard parts must constitute a large percentage of the equipment.
10. The users' own staff must be able to adapt the equipment to the inspection of a wide range of different components.

The author is not aware of any other important requirement which must be satisfied by the ideal inspection unit, but if readers think any serious omissions have been made, it is hoped that they will be reported during the discussion following this Paper.

The bench type multi-dimension inspection unit illustrated in Fig. 3 has been designed to satisfy the above conditions and to inspect the part illustrated in Fig. 2. The extent to which this unit satisfies the 10 specified conditions is given below:-

1. Condition No. 1 is satisfied because all dimensions are inspected simultaneously.

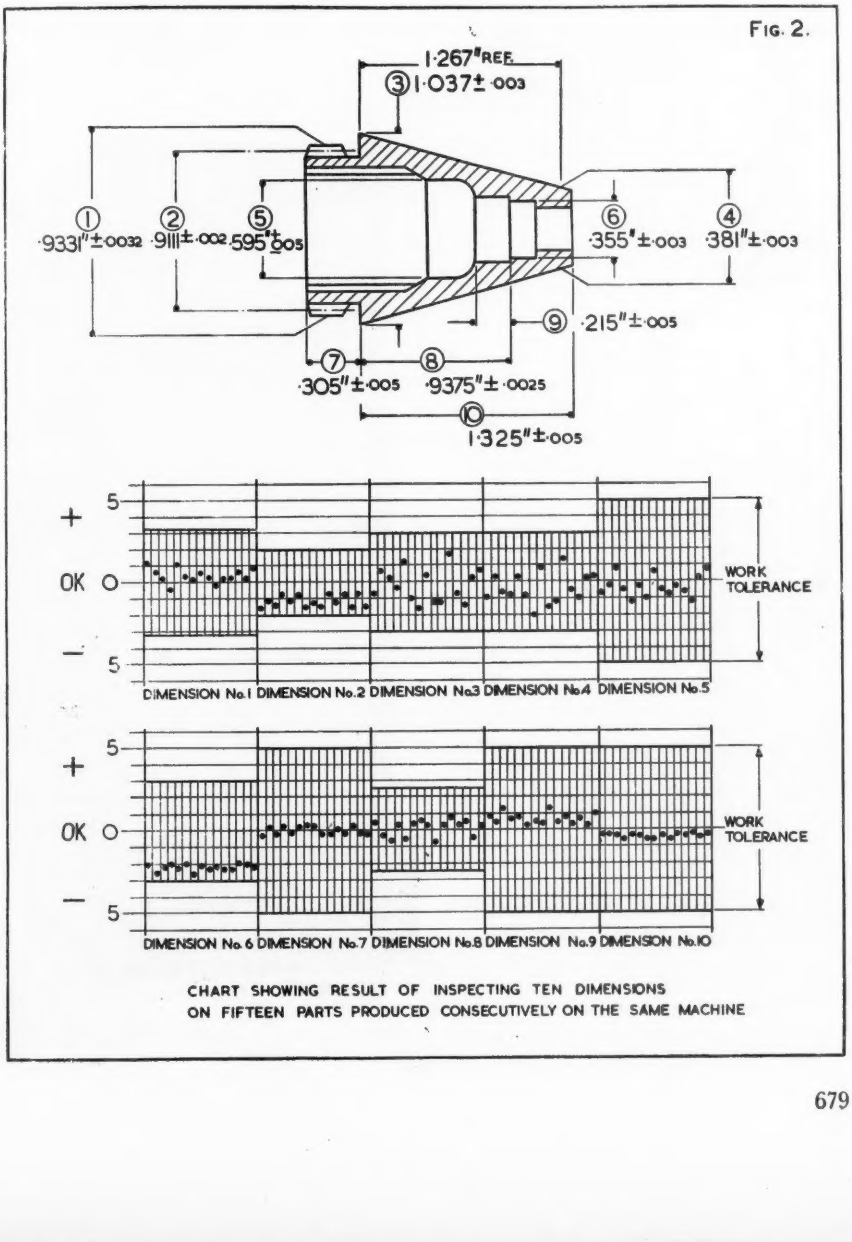
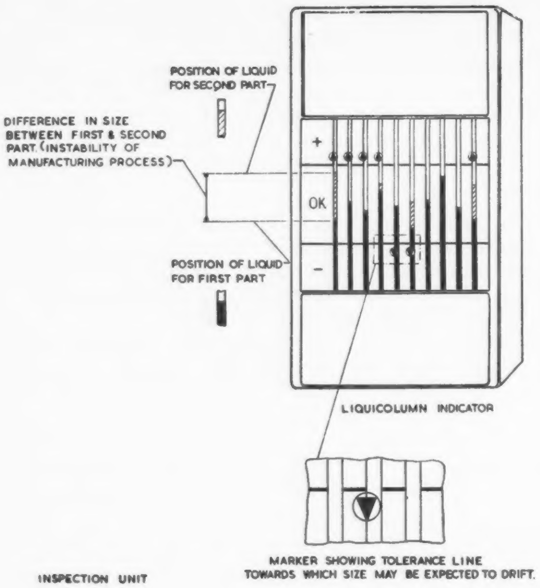


Fig. 2.
Chart showing result of inspecting 10 dimensions on 15 parts produced consecutively on the same machine.



2. Condition No. 2 is satisfied because, as illustrated in Fig. 3, a clearly marked tolerance band is provided, which is never narrower than 4″ and never wider than 6″. This tolerance band forms part of an indicator panel carrying uniformly divided scales with an effective length of 10″. The above conditions are made possible by the use of standard microvalve units of the type illustrated in Fig. 4, which provide magnifications varying from 100 to 10,000.
3. Condition No. 3 is satisfied because the indicating device incorporates a multi-tube manometer unit as illustrated in Fig. 3, and the measured size of each inspected dimension and its disposition in relation to the tolerance boundaries can be clearly seen by observing the height of the liquid in each of the tubes in relation to their tolerance boundaries. The accuracy of measurement in the equipment being described is inside a tolerance of $\pm 5\%$ of the work tolerance on all measured dimensions.

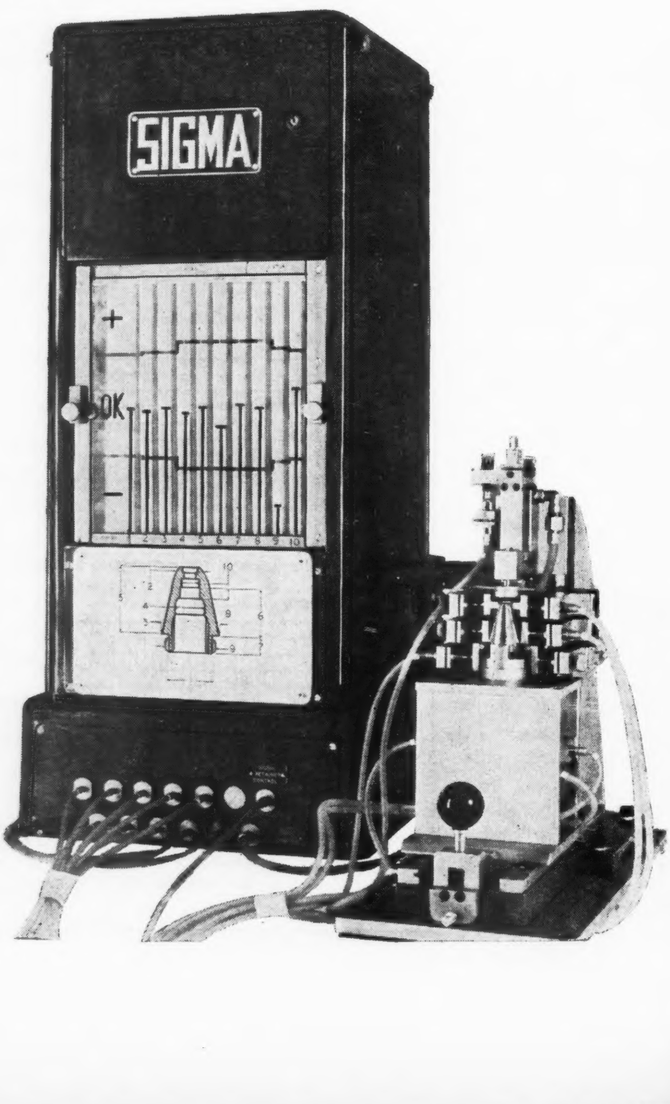
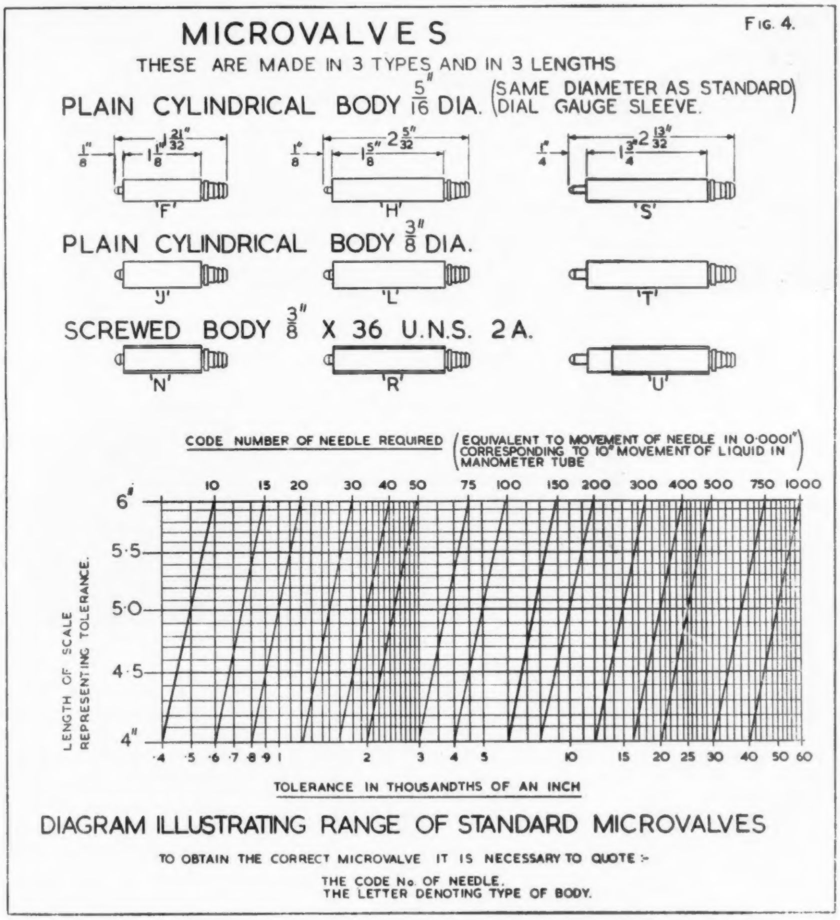


Fig. 3 *(above and right).* **Inspection unit for part illustrated in Fig. 2.**

Fig. 4.



4. Condition No. 4 is satisfied by the sign illustrated in Fig. 3 and appearing just beyond the tolerance lines towards which size is expected to drift as production proceeds.
5. Condition No. 5 is satisfied in the following manner :-
When a part is placed in the inspection unit the size of each dimension inspected is indicated by the height of the liquid in each of the separate tubes. By means of a signal retaining device, it is possible to retain the result of inspection on the indicator panel after the part has been withdrawn from the inspection unit. When the second part to be inspected is inserted in the inspection unit, the section of each of the 10 pneumatic circuits connected to the measuring units takes up a pressure corresponding to the size of the part being measured, while the portion of the pneumatic circuit incorporating the indicator tubes remains at a pressure corresponding to the size of the first part.

STANDARDS ROOM TEST REPORT.

DESCRIPTION OF PART.		BODY.		
DIMENSION NUMBER	BASIC SIZE	+ TOLERANCE	−	MEASURED DIFFERENCE FROM BASIC SIZE
1	·9131"	+ 0	− ·004"	+ ·0002"
2	·384"	+ 0	− ·006"	− ·0005"
3	1·04"	+ 0	− ·006"	+ ·0005"
4	·59"	+ ·010"	− ·0	+ ·002"
5	1·32"	+ ·010"	− ·0	− ·0015"
6	·940"	+ 0	− ·005"	+ ·0002"
7	·300"	+ ·010"	− ·0	+ ·0015"
8	·220"	+ 0	− ·010"	+ ·0015"
9	·9363"	+ ·	− ·0064"	− ·0005"
10	·354"	+ ·004"	− ·002"	+ ·0005"

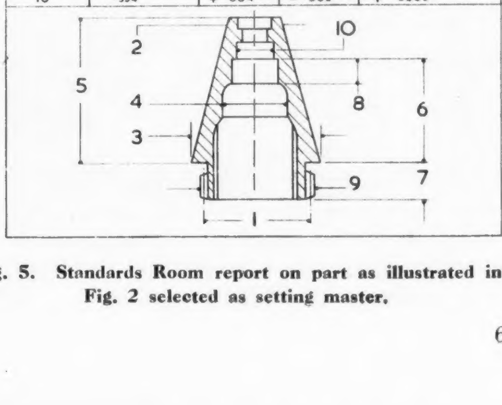


Fig. 5. Standards Room report on part as illustrated in Fig. 2 selected as setting master.

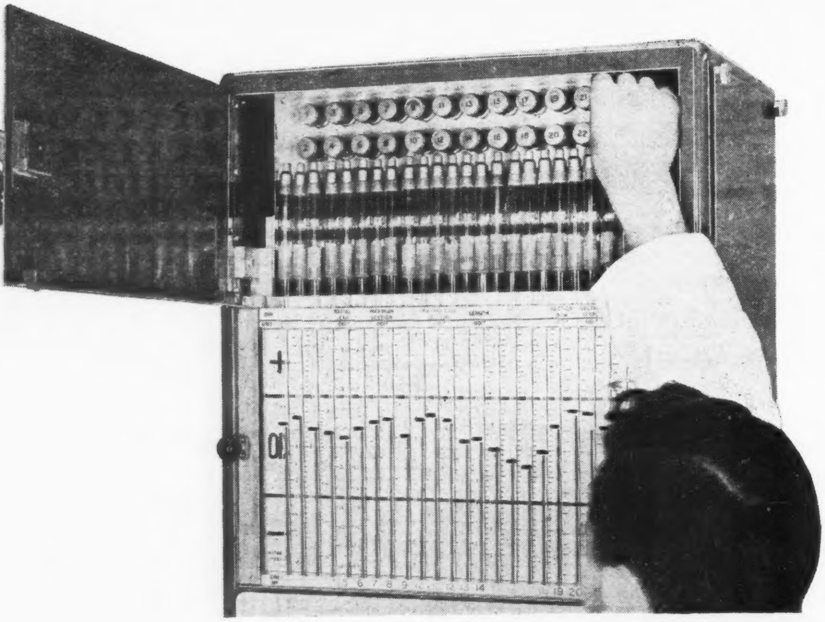


Fig. 6. Machine setter adjusting height of liquid in manometer tubes to coincide with marker lines corresponding to known size of part selected as setting master and illustrated in Fig. 5.

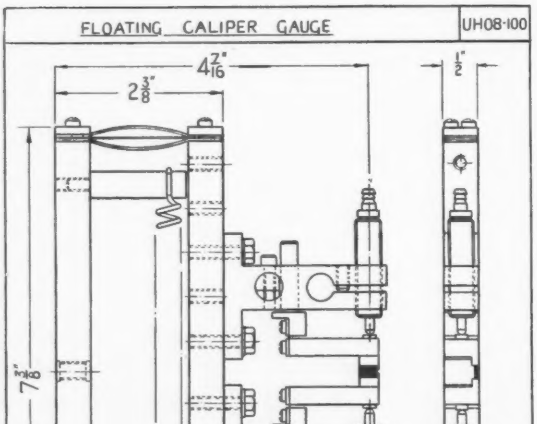


Fig. 7. Example of simple type of universal tooling used to adapt standard microvalves to inspection of wide range of parts.

By depressing a foot pedal, the 10 pneumatic circuits take up pressures corresponding to the size of the 10 inspected dimensions on the second part, and as this change takes place the height of the liquid in each of the indicator tubes moves from the position where it accurately indicated the size of the first part to the position where it accurately indicates the size of the second part. By observing the magnitude of this movement and its relation to the magnitude of the tolerance, it is possible to observe the relative difference in size between the two parts and from this the stability of the manufacturing process associated with each inspected dimension can be assessed.

When a production process of the type illustrated by the diagram shown in Fig. 2 is investigated by the technique described, it requires an inspection operation occupying about one minute to expose the whole of the technical information obtained by plotting and analysing the diagrams shown in Fig. 2 which, as already stated, occupied about 90 minutes.

6. Condition No. 6 is satisfied by using the technique illustrated in Figs. 5 and 6. Fig. 5 is a reproduction of a Standards Room report on a good quality part selected as suitable for use as a setting master. Each inspected dimension on the selected part has been very carefully measured by the Standards Room staff and the deviation from nominal size tabulated. Marks corresponding to the carefully measured size on each dimension is indicated on the diagram panel by means of the small marker lines as shown in Fig. 6. The illustration shows the operation of setting the height of the liquid

in each of the manometer tubes to correspond to these marker lines. This operation is carried out when the calibrated setting master is in the inspection position and the indicator unit is thus made to indicate to a high standard of accuracy the known size of the part selected as a setting master on all inspected dimensions.

7. The section of condition 7 dealing with toolmaker's tolerance is satisfied by using the technique described in 6 above, and the section dealing with gauge wear is satisfied by periodically placing the setting master in the inspection unit and if drift has occurred due to wear on gauge anvils, or from any other cause, the effect of this can be eliminated by resetting the indicator unit as already illustrated in Fig. 6.

8. The equipment illustrated is simple to operate and well suited to percentage inspection. It can also be used for occasional 100% inspection and, therefore, satisfies condition No. 8.

9. In the case illustrated, which is typical of current practice, about 85% of the equipment is built up from standard parts and this satisfies condition No. 9. A typical standard unit is illustrated in Fig. 7 and a simple inspection fixture in which 97% of the parts are standard is illustrated in Fig. 8.

10. Experience has shown that it is possible for skilled mechanics, without drawing office assistance, to build up fixtures for the inspection of simple parts and when drawing office assistance is required, it is of a type well within the capabilities of the average jig and tool draughtsman. This satisfies condition No. 10.

Additional attachments or refinements

The inspection technique and supporting equipment just described was designed to satisfy specified and fundamental inspection requirements. The technique may be further improved by the addition of attachments in much the same way that extra attachments or refinements may be added to cameras, microscopes and automobiles. The following have proved useful in practice and can be incorporated in or added to, the standard equipment when required :-

1. Investigations into the stability of automatic manufacturing processes will be undertaken on an increasing scale in future years and a need exists for a device which will automatically record this feature as part of a normal inspection process. Fig. 9 illustrates a section taken from an automatic recording which shows the

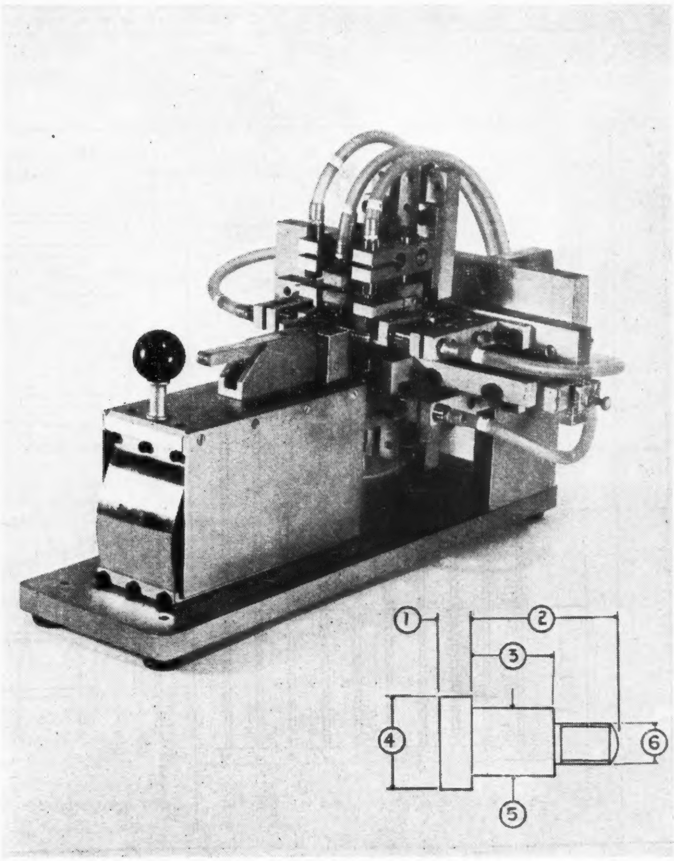


Fig. 8. Example of small universal inspection fixture using 97% standard parts to inspect part shown in sketch.

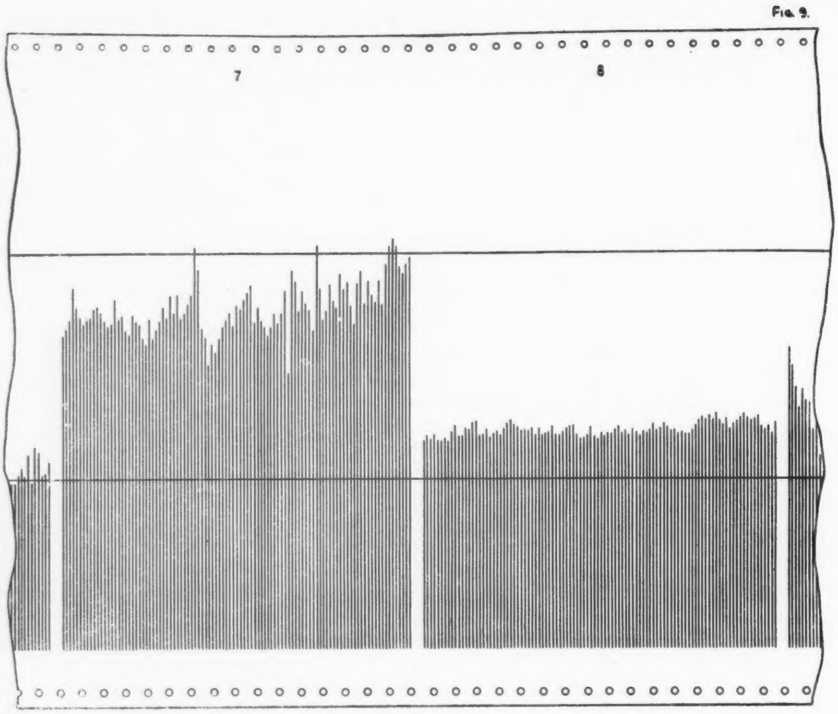


Fig. 9. Part of record from automatic recorder designed to show degree of stability in manufacturing process used for producing each inspected dimension.

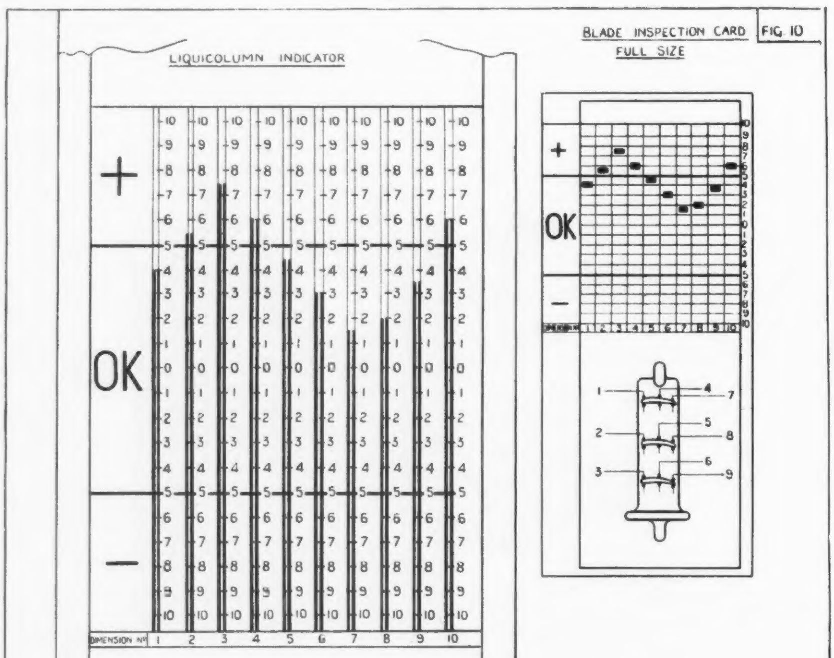


Fig. 10.

Permanent record of measured size of 10 inspected dimensions recorded by disposition of holes in punched card.

degree of stability in a sample group of 100 parts. The standard attachment will record up to 12 dimensions simultaneously and in the sample recordings illustrated, dimension No. 7 is seen to be unstable while dimension No. 8 is very stable and near the low limit of the tolerance. The attachment is designed for fitting to any of the standard inspection units described and is usually used for short tests only, so that it is possible by one recording unit to record the performance of many machines.

2. An alternative method for permanently recording dimensional information about a manufacturing process is to arrange for the information to be tabulated, so that the data for single parts is grouped together instead of the data for single dimensions as illustrated in Fig. 9. The individual heights of the liquid in the manometer tubes of the liquicolumn unit, at the time of inspecting a particular part, can be permanently recorded by the disposition of punched holes in a punched card to an accuracy of about one-fortieth of the scale length, as shown in Fig. 10. This type of recorded data can be provided for all parts inspected, or for sample batches as required. When dimensional information is available in the form of standard type punched cards, it may be further classified and tabulated in many different ways, including the form shown in Fig. 9, by standard and usually existing office accounting equipment. It is possible automatically to calculate standard deviations, mean size and many other features. One new use for recording dimensional data on punched cards is to record the size of selected parts on cards as shown, and after some further operation which may, as in the case illustrated, be etching a forging or running test blades in an engine, carry out a further inspection operation and punch the new dimensional information on the same card. The difference between the spacing of the two sets of punched holes shows the change in size which has taken place during the process under investigation.

3. A further application in the recording of inspection information on punched cards is to arrange for the machine to punch out automatically an inspection card of the type illustrated in Fig. 11. This card records the dimensions which are outside the plus or minus tolerance boundaries. The example illustrated forms part of a fully automatic inspection machine inspecting 56 dimensions simultaneously on a 6-cylinder crankshaft. A punched card is only issued when rejects are detected and the data provided by the card has proved of considerable value to the section responsible for rectification.

4. One important feature of the liquicolumn type indicator unit, with its uniformly divided scale, is the ease and accuracy with which it can be set by means of a single calibrated setting master.

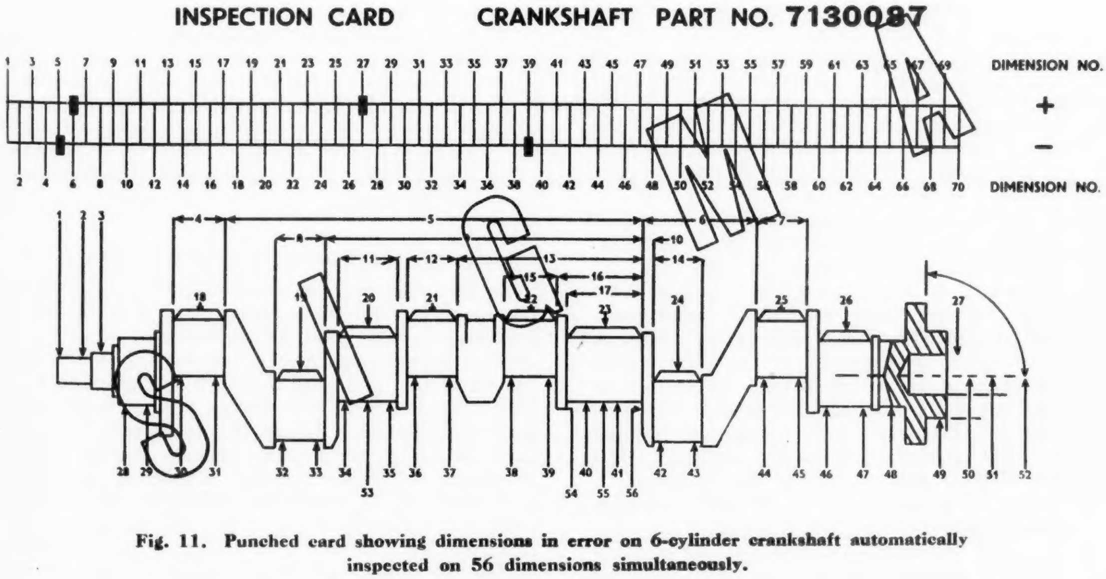


Fig. 11. Punched card showing dimensions in error on 6-cylinder crankshaft automatically inspected on 56 dimensions simultaneously.

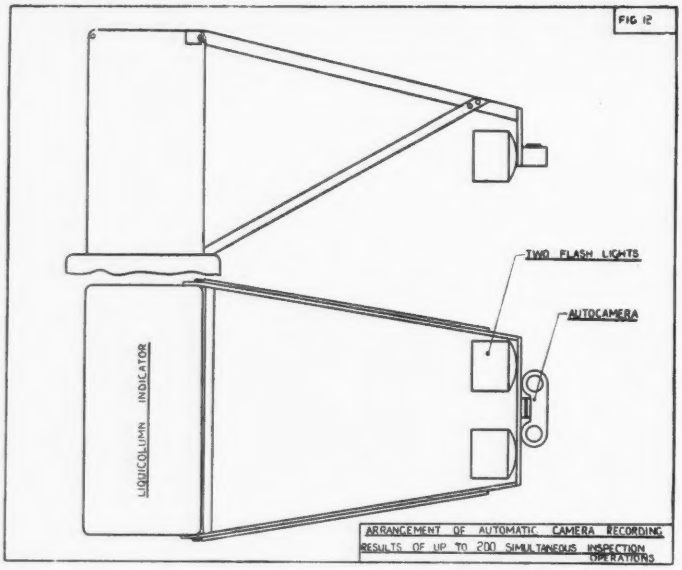


Fig. 12.

Diagram showing arrangement for automatic camera recording result of up to 200 simultaneous inspection operations.

The almost insurmountable difficulties encountered in the manufacture of high and low reject setting masters for very complex parts have caused the equipment to be used for final 100% inspection. When this occurs the equipment must be operated at the highest possible speed. Cycle time and operator fatigue can be reduced if the need to study the inspection panel for each part inspected can be avoided. Arrangements have, therefore, been made for a green O.K., and a red reject signal light to be fitted in an easily observed position, and for the O.K. light to be automatically illuminated if all dimensions are inside tolerance. It is only necessary for the inspector to study the liquicolumn indicator panel when the red light is illuminated, indicating that the part is faulty on one or more dimensions.

5. A further development in the field of automatic recording of inspection data is to use an automatic camera as illustrated in Fig. 12. The camera is usually arranged to produce complete coloured photographs of the liquicolumn indicator panel and up to 200 photographs can be made on a single film. The photographs are taken automatically without any action on the part of the operator, the camera and flash bulb being operated by an electrical impulse sent out from the base of the machine. The recorded information on the film is used for a variety of purposes, details of which are outside the scope of the present paper.
6. A system of recording dimensional information which is specially suitable for parts requiring inspection on a small number of dimensions is to make use of the strip type multi-pen recorder and instruments giving up to six simultaneous records are in successful operation.

Fig. 13 illustrates a combined measuring unit and four-pen recorder designed to inspect the four important dimensions on a wide range of small shafts of the type used in watches, clocks and similar mechanisms. The results obtained from inspecting several sample groups of parts made on the same machine are all recorded on the same card, which is usually kept near the machine producing the parts. A reproduction of a typical card illustrating the results obtained in this instance by inspecting a group of nine shafts on three successive tests to investigate possible errors in the equipment, is included in the illustration.

Control of transfer type manufacturing unit

In line and circular track transfer type manufacturing units form an important part of automation, especially in the great automobile and similar industries in this and other countries. The efficient control of the quality of the parts produced on this high value and very high output type of plant is of great importance. Using the techniques already described, it is possible to provide one or more automatic inspection stations as part of the basic equipment. For maximum efficiency these units should be planned at the same time as the manufacturing equipment. The indicator panel shown in Fig. 14 forms part of an inspection unit which

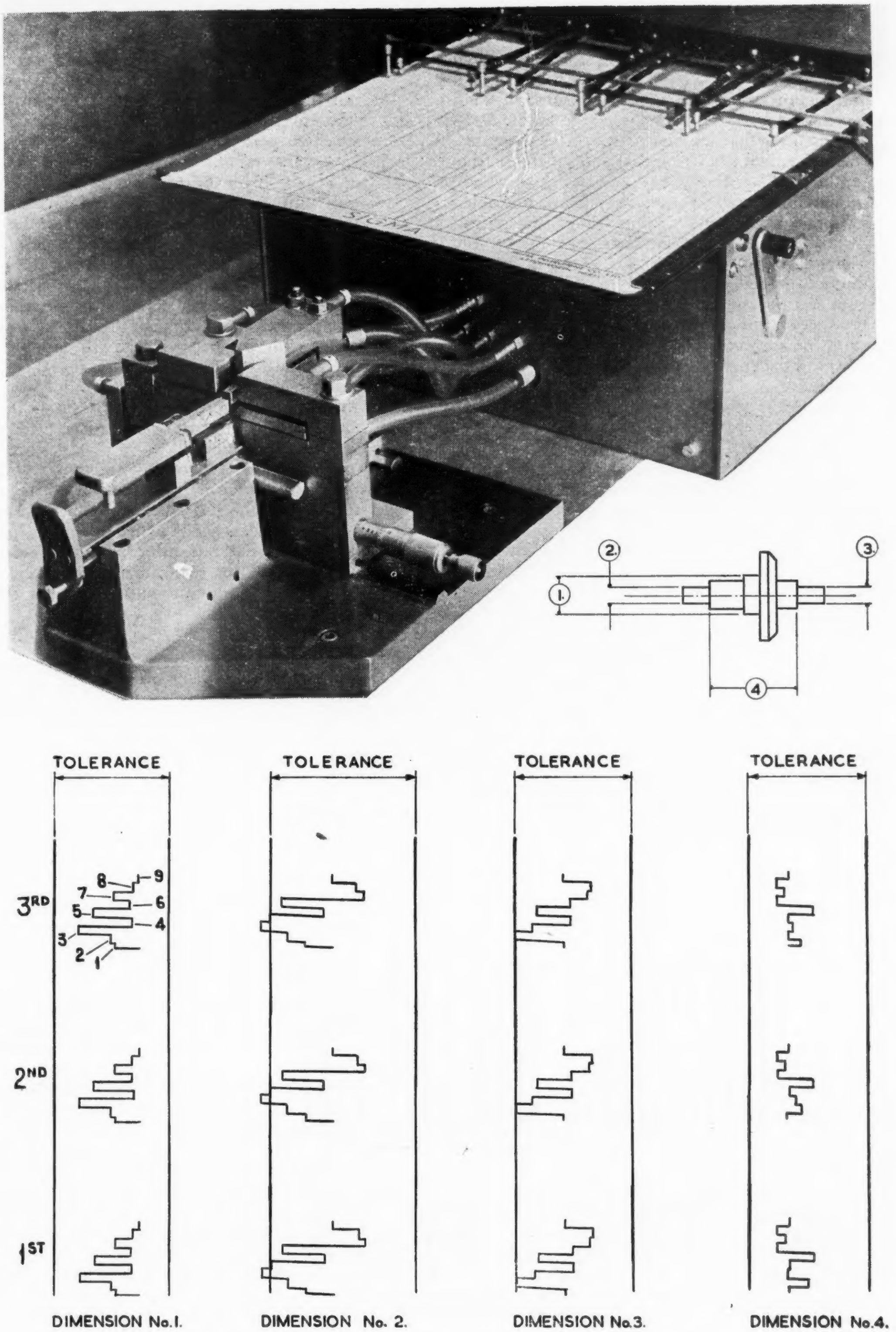


Fig. 13. Measuring instrument and automatic 4-pen recorder used to record simultaneously four important features on small shaft.

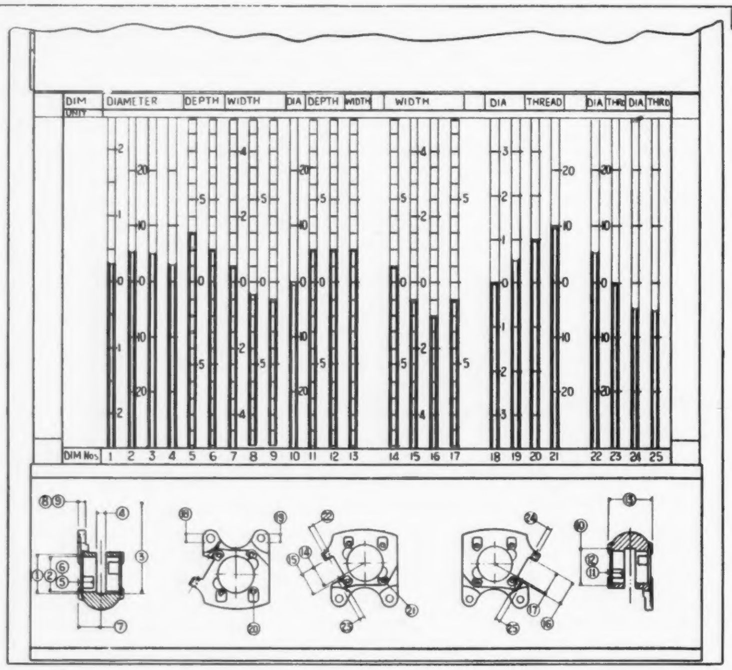
satisfies all the known requirements for controlling the quality of the parts produced on this type of high production machine. The information and service provided by the unit includes the following :-

1. By observing one complete cycle of the machine, the movement or absence of movement of the liquid in the manometer tubes indicates which dimensions are stable and which are unstable. It is the duty of the machine setter, the patrol inspector and finally, management up to the highest level to see that the whole of a production process which was planned to be stable is operating as planned. In practice, very few production processes satisfy this condition because no means is provided for measuring this most important feature in engineering production.
2. It is possible at any time production is in progress to observe the accurately measured size of all inspected dimensions on the last part automatically inspected by the inspection unit, and to note the disposition of this size in relation to the tolerance boundaries. In particular, it is possible to observe the disposition of size in relation to the boundaries towards which size can be expected to drift as production proceeds. This information, together with a knowledge of the stability of the process, enables the machine setter to decide whether or not the equipment can be relied upon to continue to produce 100% good parts for a further specified period of time.
3. If, because of unforeseen circumstances or lack of attention by the machine setter, the inspection unit detects that a faulty part has been produced, the production line can be automatically stopped and an agreed type of alarm given. If because of the nature of the process it is decided that two or, if necessary, three or more consecutive rejects must be produced before production is stopped, this can be arranged, along with a device which will suitably mark individual rejects or arrange for their automatic segregation.
4. An automatic card punching unit of the type illustrated in Figs. 10 or 11 can be fitted to the machine if required.

Separate " in the line " inspection units

In addition to the use of an automatic inspection unit of the type described, which forms an internal part of the automatic transfer line, this new technique can be used for separate inspection by hand, semi-automatic, or fully automatic machines, situated

FIG 14



INDICATOR PANEL FROM AUTOMATIC INSPECTION UNIT USED ON IN LINE TYPE TRANSFER MACHINE

Fig. 14. Indicator panel from automatic inspection unit used on in-line transfer machine.

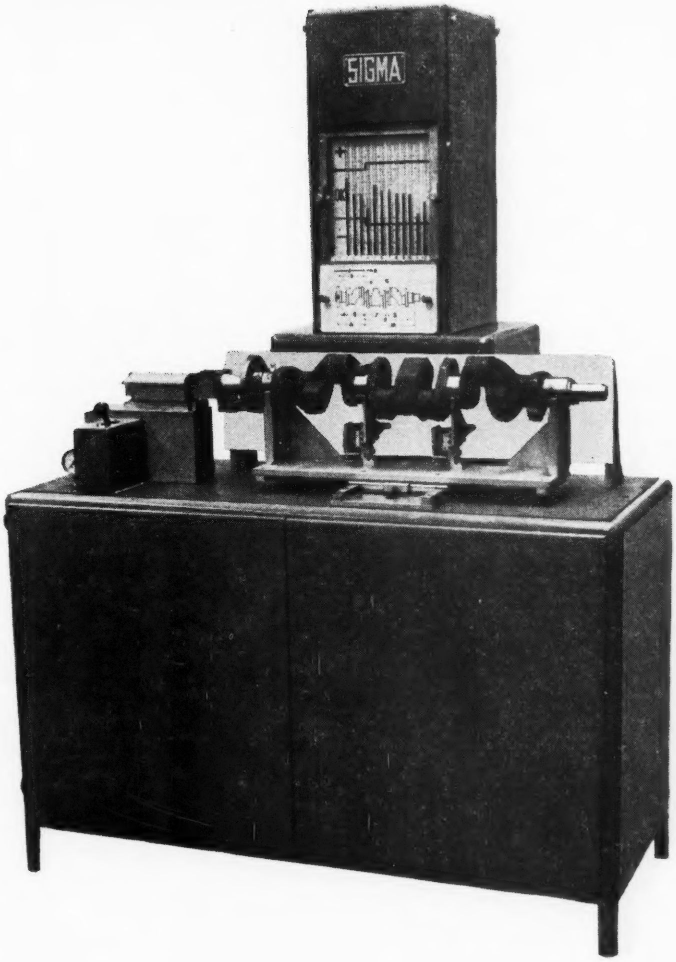


Fig. 15. Inspection machine for controlling turning operation on 6-cylinder crankshaft.

at the end of a transfer line or between machines in a normal type production line. Such equipment is usually used for percentage inspection and may cover the work of one or several machines. Two typical machines used for this type of inspection are illustrated in Figs. 15 and 16.

Conclusions from study of control techniques for stable manufacturing processes

The simple philosophy on which the whole of the foregoing technique is based is that it is good engineering and good sense to provide the person in control of a complex manufacturing process, such as that carried out on a multi-station automatic production machine, with the means whereby he can see both clearly and quickly the nature and the magnitude of the changes in quality of the product which occur as production proceeds.

Accurate measurement most certainly reveals that changes which are important and significant do occur, and whose presence current inspection techniques do not reveal. This clearly unsatisfactory condition cannot continue indefinitely, and it is hoped that the proposals put forward in the Paper provide one possible fruitful solution of this important and interesting problem.

Group B. Unstable manufacturing processes

The wide range of grinding machines in current use form an important group of manufacturing equipment which, because of the relatively rapid breakdown of the grinding wheel, require frequent adjustment to maintain accuracy of size in parts produced. The type of adjustment required on modern grinding machines to compensate for wheel wear is usually a simple operation consisting of a small angular rotation of a feed wheel or operating a push button and it, therefore, becomes a relatively simple matter to apply feed-back from a measuring head to the machine, so that it becomes fully compensating for changes in size due to wheel wear or any other cause.

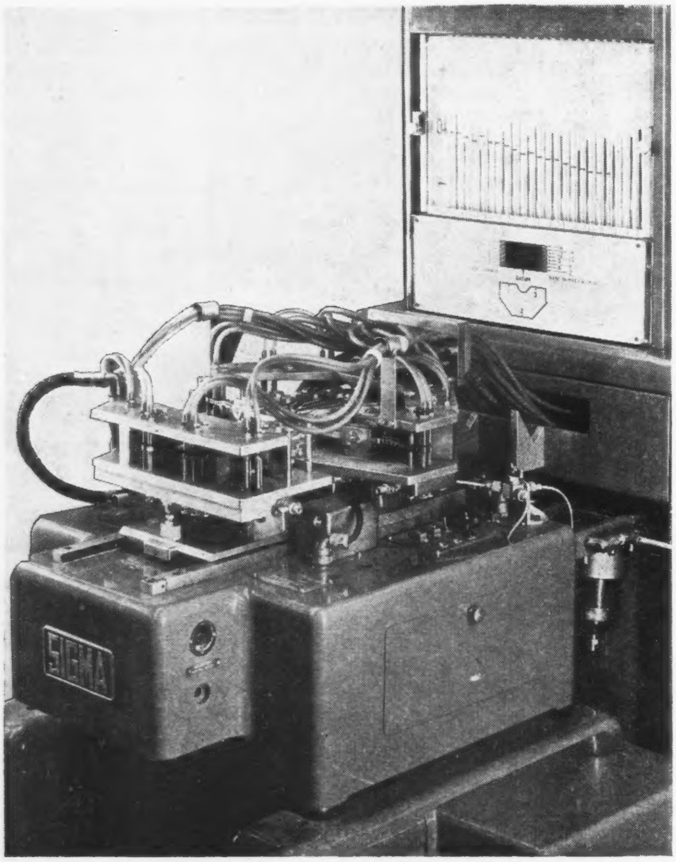


Fig. 16. Inspection machine for controlling assembly of aluminium plates in high accuracy variable condenser stator unit.

The following are considered to be a good cross-section of the many forms of grinding machines in current use and will be used as examples to demonstrate typical modern methods of control :-

1. Plain cylindrical grinders (traversing type).
2. Plunge-type cylindrical grinders (e.g., external crankshaft grinders).
3. Cylindrical grinders arranged to produce parts to a predetermined fit tolerance.
4. Through feed centreless grinders.
5. Plunge type centreless grinders (e.g., grinding five-stepped shaft).
6. Surface grinders (e.g., vertical spindle machine with segmental wheel).
7. Internal grinder (e.g. bores $1\frac{1}{2}''$ or larger in diameter, and suitable for inspection during grinding).

Plain cylindrical grinder *(traversing type)*

A very effective and simple method of applying efficient control to a plain cylindrical grinder is to fit a grinding gauge which will enable the operator to view the size of the part continuously during the grinding operation. With this easily obtained and highly accurate technical information, the operator can manipulate the machine manually, and the task of producing high quality parts is greatly simplified. A suitable gauge and indicator in use on a simple traverse grinding operation is illustrated in Fig. 17. A large number of parts were made without difficulty to a tolerance of 0.00002" on a machine whose inherent accuracy was, in itself, not suitable for high precision work of this type. The operation was possible by the ease with which the operator was able to make the necessary manual adjustments. An alternative type of grinding gauge for table mounting is illustrated in Fig. 18.

If conditions can be established where the inherent accuracy of the machine is sufficiently high, and it can be assumed that it is satisfactory to measure the part at one place, and this measurement to be representative of the whole surface, it is possible to apply fully automatic control. An efficient type of control unit for cylindrical grinders is illustrated in Fig. 19, which shows, also, the rate of stock removal on a time basis. The curve in this illustration shows the

three selected sizes at which the controller operates, namely :-

1. Change from rough to finish grind.
2. Change from finish grind to spark out.
3. Withdraw wheel at finished size.

This type of controller can be used in conjunction with grinding gauges of the type illustrated in Figs. 17 and 18.

The above techniques have also been applied to high precision cylindrical grinders of the type used for finish grinding pistons for fuel injection equipment, and hydraulic gear of the type used on high-speed aircraft. This type of component demands that the fit between mating parts be held to extremely fine tolerance, and it is not uncommon for production grinders operating on fully automatic sizing cycles, and using equipment of the type described, to work on a quantity basis to tolerances of less than one-ten-thousandth of an inch.

Plunge type cylindrical grinder (*e.g., crankshaft grinder*)

The standard three-stage controller can also be used in conjunction with the grinding gauge illustrated in Fig. 20 which is designed specially for parts such as crankshafts which require large stock removal, and when near finished size, the ability to examine small errors in roundness on the part produced.

A supplementary dial of low magnification is also provided on this gauge to indicate when the part is approaching the size at which the machine will changeover to fine feed. This supplementary information is useful for several purposes and, in particular, enables the operator to see that no very serious errors in roundness are present and that the part is cleaned up completely before starting the fine feed.

Cylindrical grinder set to produce a predetermined fit tolerance

On certain types of high precision work it is desirable to obtain the most accurate fit possible between mating components, both of which should be held to extremely high standards of accuracy for geometric shape. The mating parts usually consist of a plain plunger which must fit into a plain cylindrical bore, which is usually made of good geometric shape by honing or other suitable means after finish grinding. This creates a condition where the cylinders vary in size over a relatively wide range, and it is required to grind a piston to each individual cylinder so that the predetermined fit tolerance is established.

A completely automatic sizing arrangement has been developed to meet this need and equipment which can be fitted to standard automatic grinders is illustrated in Fig. 21.

If it is required to use the above technique on manually operated machines, this can be done by using indicating equipment designed to show the fit tolerance and also the change in fit which takes place as metal is removed from the piston during the grinding operation. The equipment illustrated indicates on a single dial the difference in size between the

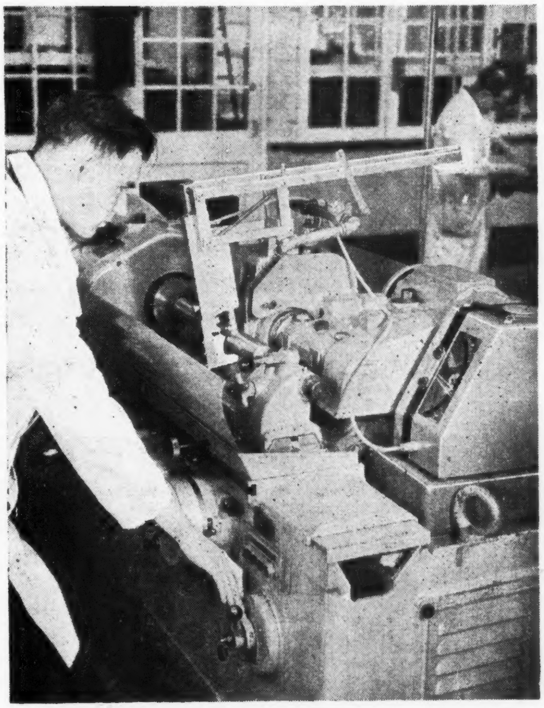


Fig. 17. Continuous counterpoise type grinding gauge used on manually controlled cylindrical grinding machines.

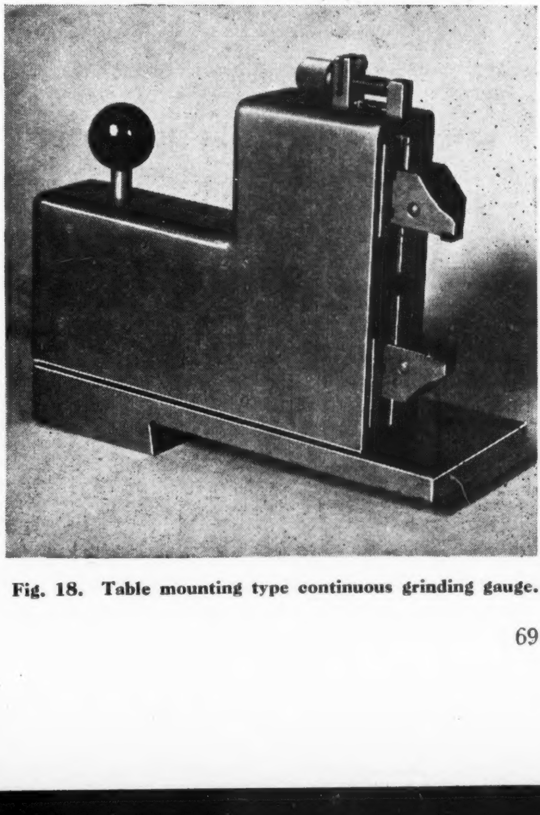


Fig. 18. Table mounting type continuous grinding gauge.

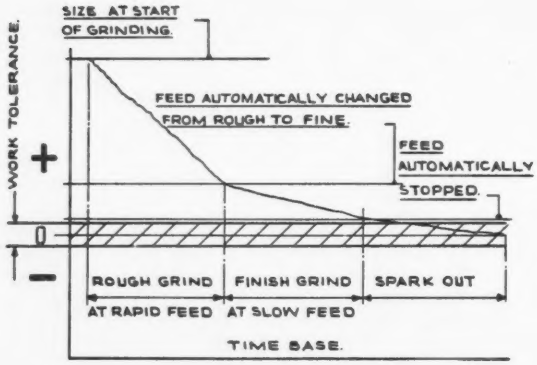


Fig. 19. Automatic control cycle suitable for use on cylindrical grinding machines.

Fig. 20 *(right)*. Three-stage controller of the type used to obtain the three-stage control illustrated in Fig. 19.

cylinder into which the plug is inserted and the piston which is being ground, and on to which the caliper gauge is operating.

Through feed centreless grinder

A simple form of control on a through feed centreless grinder is obtained by inserting a continuous automatic gauging unit, of the type illustrated in Fig. 22, in the outlet chute of the grinder and allowing this device continually to indicate the size of the parts as they leave the machine during normal production.

In the equipment illustrated, special arrangements have been made to suppress the disturbance which would normally occur when the joint between two parts passes the jets of the air measuring system. In use it is found that the person in control of the machine, or any other authorised person, can at any time, and by simple observation, see very clearly the size of the parts as they are produced and, in addition, the disposition of this size in relation to the tolerance boundary.

If the preliminary turning or grinding operation has been carried out in a satisfactory manner and the parts presented to the machine are inside the tolerance specified for parts prior to finish grinding, the change which will occur in the size of the parts as they leave the grinding machine will be a slow drift in an upwards direction due to the slow breakdown of the grinding wheel. This slow change of size can be observed by the operator and it is possible to arrange for the parts to be manually graded into the appropriate categories, as shown on the indicating unit. When the size of the parts leaving the machine approaches near the top boundary of the tolerance, the operator can manually adjust the machine so

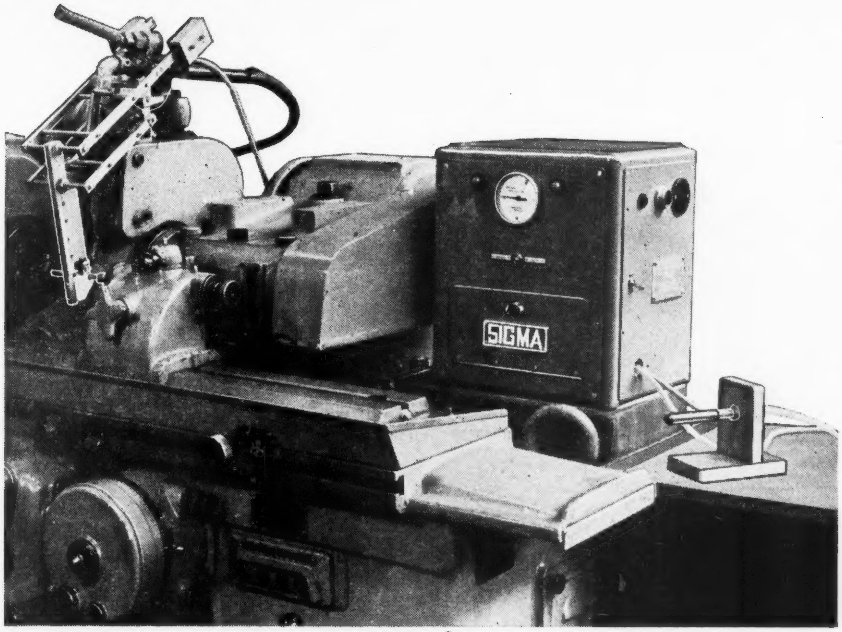


Fig. 21. Automatic control equipment of the type used to produce a predetermined fit tolerance.

that the distance between the grinding wheel and the control wheel is slightly reduced, and observe the effect of this adjustment on the indicator, and by this means, bring the size of the parts produced near to the bottom limit.

A further development of this simple technique is to replace the continuous indicator by the combined continuous indicator and recorder of the type illustrated in Fig. 23. This instrument enables the operator to observe continuously the size of parts as they are produced, and carry out manual machine adjustment and grading as previously described, but with the added advantage that at the end of each day, or after a particular batch of parts has been completed, it is possible to take from the recorder a strip of chart on which is an accurate record of all the changes in size which have taken place during the period under review. This simple strip of chart can now be accepted as the certificate of inspection for the parts produced, and under normal circumstances, no further inspection is necessary.

The instrument illustrated is also provided with two supplementary pens which, when set, will automatically draw the predetermined tolerance lines on the chart as it feeds through the instrument. Arrangements are also available whereby the speed of the chart can be changed over a wide range. For investigation purposes it is found that a rapid chart speed reveals information of considerable value, while for normal production a very slow chart speed provides all the information required.

The technique for fully automatic control on through feed centreless grinders is to arrange for the spacing between the feedwheel and the grinding wheel to be automatically adjusted, as dictated by the equipment which is continuously and automatically measuring the size of the parts as they pass through the measuring head on the outlet side of the grinding machine.

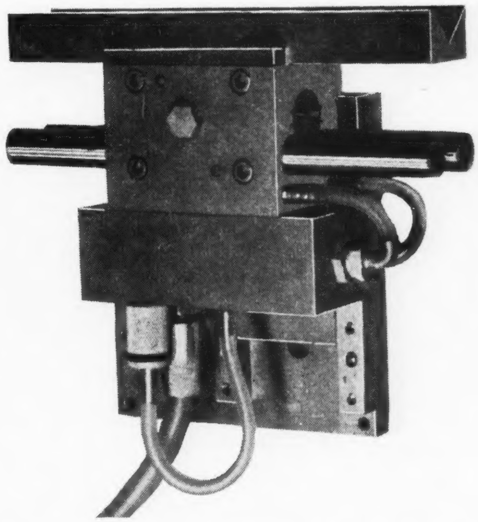


Fig. 22. Continuous measuring and indicating unit for use on through-feed centreless grinders.

Fig. 23. Combined continuous indicator and recorder for use on cylindrical and centreless grinding machines.

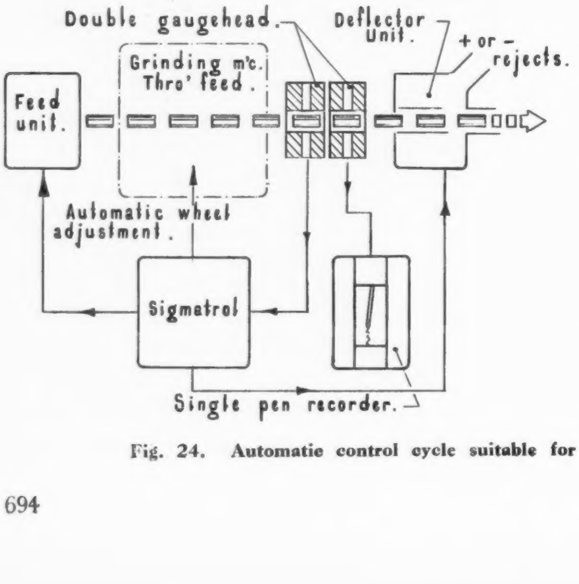
When fully automatic control is used, it is usual to use a gauging unit incorporating two pairs of measuring jets, one of which is designed to impulse the automatic controller, the second pair designed to operate an automatic recorder. The general arrangement of the equipment and the type of approximately self-repeating cycle which takes place during the normal production is illustrated in Fig. 24.

From the graph which shows the relationship between size and time it will be seen that as breakdown of the grinding wheel occurs, the size of the parts produced is allowed to increase up to a determined size marked on the graph as "upper control limit". The first parts to reach this size will cause the controller to send out an electrical impulse as shown in the diagram to an appropriate unit on the machine, which will rotate the feed screw or operate any other feed mechanism by a predetermined amount, the purpose of which is to reduce the size of the parts produced to the value marked on the graph as the "lower control limit". Whether this automatic impulse to the feed mechanism causes the parts produced to be reduced to the predetermined value as planned depends upon a number of factors, the chief of which is the ability of the slide of the machine to respond consistently to small increments of feed.

If it is found that for any reason the infeed of the slide is in excess of the predetermined amount, and the size of the parts produced falls below the lower boundary of tolerance, a second impulse is automatically sent out from the controller, which carries out the dual task of stopping the feed unit and operating a simple deflector chute shown in the diagram which, if situated about four feet from the measuring head, will prevent any faulty parts passing through into the O.K. box.

The second pair of jets in the measuring head is used to impulse a continuous strip recorder of the type previously described which, for investigation purposes, can be run at a high speed and on normal production at much slower speed. As previously described the chart can be removed from the recorder when required, and the strip of chart taken as a certificate of inspection for the parts which have been ground while the record was being drawn.

For these cases where very high precision parts such as gudgeon pins must be produced at a high rate from turned blanks manufactured to a relatively wide tolerance, it is necessary to use several grinding machines followed by one or more centreless lapping



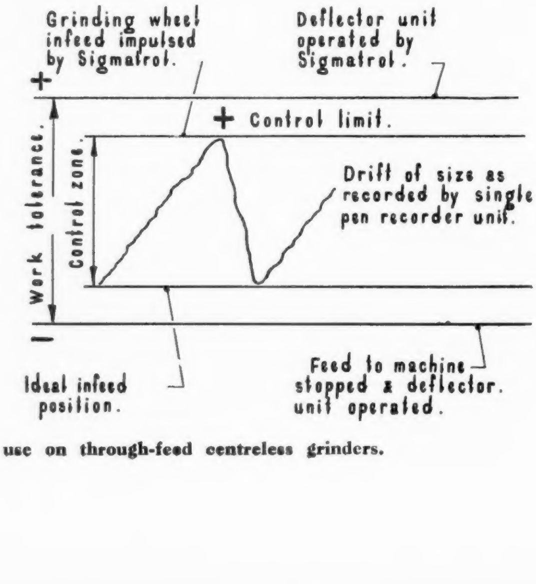


Fig. 24. Automatic control cycle suitable for use on through-feed centreless grinders.

machines to obtain the fine degree of surface finish. To meet this need, grinding and lapping machines have been arranged in tandem as illustrated in Fig. 25, with an automatic controller controlling size on the outlet side of each grinding and lapping machine.

Arrangements can also be made for the size of the parts as they leave each machine to be continuously indicated on a liquicolumn unit, or continuously indicated and recorded on a multi-pen recorder which can cater for up to six records simultaneously.

On the outlet side of the final machine a grading unit can also be provided which will automatically measure each part and deflect the part into an appropriate work container depending upon the grade of the pin produced. This is an ideal example of applying highly developed control equipment to production and arranging for the final inspection unit to be linked up with the production device so that it becomes part of the production equipment.

Plunge type centreless grinder *(e.g., grinding five-stepped shaft)*

Instances do occur in engineering production where it is necessary to grind several diameters simultaneously on the same shaft, and the case being reviewed is where this requirement is satisfied by grinding the shaft on a centreless grinder. The technique used is to arrange for the grinding wheel and the feed wheel to be shaped by means of high precision profile plates so that the profile of each wheel corresponds to the profile of the shaft which is to be ground. The technique of applying automatic control to such a grinder consists of making arrangements whereby the part, when finish ground, is automatically removed from the work-rest and passed into a measuring station where all five diameters are measured simultaneously.

The result of inspection can be shown on a five-tube liquicolumn unit of the type described in the earlier part of the Paper or, alternatively, on a five-pen automatic combined recorder and indicator. The size of the part will increase due to wheel wear as previously described, and arrangements are made for the controller to be impulsed when a predetermined diameter, usually the largest diameter on the shaft, reaches the upper control limit. When this occurs, the setting of the machine is automatically adjusted so that all diameters are produced to a slightly smaller size near the low boundary of the tolerance.

When this type of automatic adjustment has been made a large number of times, the irregular wear on the various surfaces of the grinding wheel will cause the spread of size between the various diameters being simultaneously ground to take up an objectionably large percentage of the tolerance band, and it is when this occurs that the grinding wheel requires redressing. To cater automatically for this condition there is fitted into the controller, illustrated in Fig. 26, a predetermining counter which can be set to any

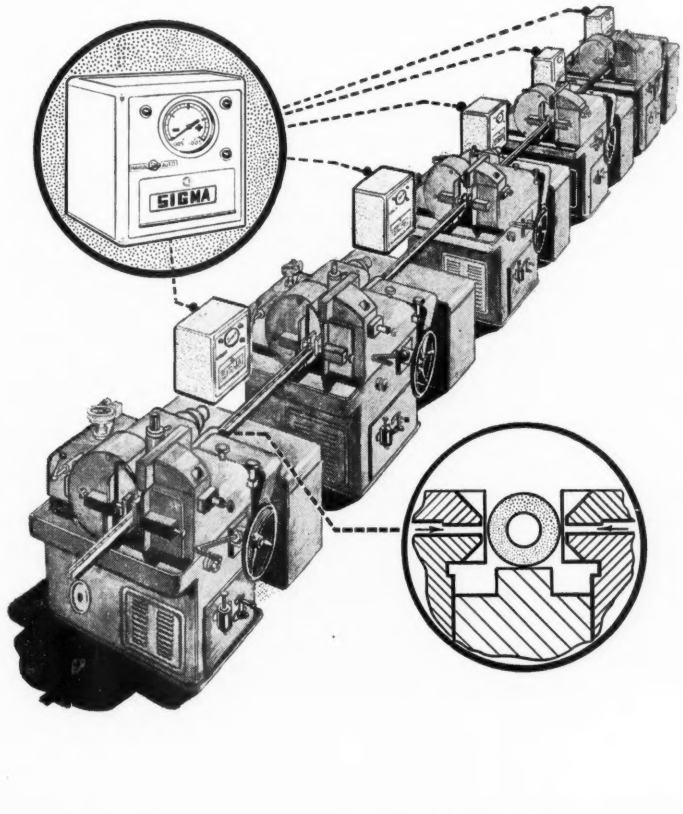


Fig. 25. Group of through-feed centreless grinders arranged in tandem with automatic control fitted to each machine.

Fig. 26.
Controller incorporating predetermining counter to impulse automatic dressing of grinding wheel and provide type of control illustrated in Fig. 27.

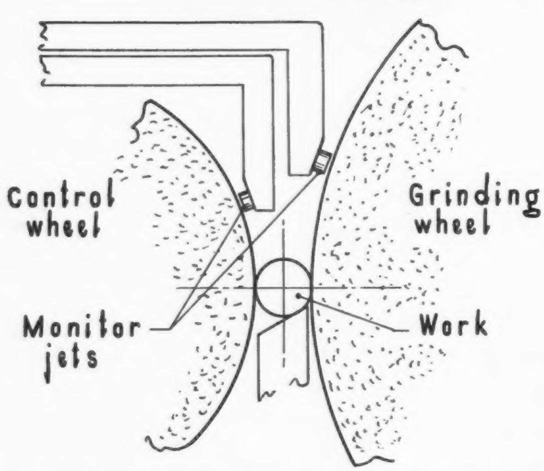


Fig. 27. Type of control applied to plunge-type centreless grinder where five diameters are ground simultaneously.

agreed number, and after a predetermined number of shafts have been ground, the grinding wheel will be automatically redressed.

When this has occurred, the next task is so to position the surface of the grinding wheel that it will produce a satisfactory part without any reference to the main gauging unit which measures the part after it has been finish ground. To cater for this condition, a measuring jet is arranged to operate on a predetermined surface of the grinding wheel, and the wheel is automatically brought closer and closer to the control wheel until a predetermined distance has been established as set up by the clearance between the jet and the surface of the grinding wheel, as illustrated in Fig. 27. When this condition has been established, the part being ground is automatically transferred into the normal gauging head and a new part fed into the grinding position. Automatic size control is then switched in and production proceeds as previously described.

Operating on this basis, it is found that it is possible to manufacture parts to tolerances of four-ten-thousandths of an inch including automatic redressing of grinding wheel.

Surface grinder *(e.g., vertical spindle segmental wheel)*

There is a wide variety of surface grinders used in engineering production, but the one which will be selected to demonstrate automatic control in the present Paper is the type on which the spindle is mounted vertically and carries a large segmental type grinding wheel. It is used for heavy stock removal on such parts as cylinder blocks, connection rods, etc., and where the part from the rough stamping or casting must be ground down to a predetermined size. To meet this condition, it is necessary for the effective surface of the grinding wheel to be brought down to or controlled within a fine tolerance to a fixed distance from the moving platen on which the work is mounted. This moving platen on which the work is mounted can be considered as being in a fixed position in the vertical plane in relation to the main framework of the machine and it is, therefore, permissible to mount a measuring jet in a fixed position in relation to the frame of the machine as illustrated in Fig. 28. The jet illustrated is arranged in a position where it can detect the position of the effective surface of the grinding wheel, but will not come into contact with the work being ground.

When the wheel is rotating under production conditions the measuring jet is operating upon a grinding wheel of very rough structure and, in addition, is affected by the open spaces between the segments of the wheel. Because the equipment is operating as a rather complex type of comparator, these indeterminate factors do not seriously affect the efficiency of the equipment, which operates to a high standard of accuracy because the effect of these factors is consistent throughout the whole of the operating cycle.

Arrangements are made in cases of very heavy stock removal for the wheel to be slowly fed downwards at a predetermined rate until the grinding

wheel approaches the measuring jet and, if required, a three-stage cycle of operations, as illustrated in Fig. 19, can be carried out.

The alternative arrangement is where a small amount of stock removal is required and it is necessary to keep the grinding wheel in a predetermined position in much the same way as that operating on a through feed centreless grinder. If this type of control is required the cycle of operations would be similar to that illustrated in Fig. 24.

Internal grinder *(eg., bores $1\frac{1}{2}''$ or larger diameter and suitable for inspection during grinding)*

In the process selected as the example for internal grinding, the grinding wheel and measuring contacts occupy the space shown in Fig. 29. When a true diameter is measured, two inspection contacts are used, as shown at Fig. 29(a). In certain circumstances, it is more convenient to use a single contact (Fig. 29(b)). In this latter case, the measuring device responds to a change of radius from the centre about which the part is rotating. When centreless internal grinders are used, the part is supported on rollers as shown by dotted lines in Fig. 29(b) and the equipment responds to changes in wall thickness.

Machines used for this type of work usually incorporate automatic wheel dressing at the end of rough grinding. It is, therefore, customary to fit a two-stage controller. When a preset size is reached, the Sigmatrol sends out an impulse to the electro-hydraulic control in the machines, which withdraws the wheel and initiates wheel dressing, The wheel then returns and continues to grind at a reduced rate. The measuring unit then detects when the part has reached finished size and the Sigmatrol sends out a second impulse which terminates the cycle. If automatic loading is used, the finished part is ejected, the chuck reloaded and the cycle repeated.

Final inspection

The philosophy advocated in the present Paper is that everything possible should be done to control the quality of the product at the only place where the quality of the part can be influenced, that is, during the manufacturing process. It is further claimed that this condition can be satisfied by the use of machine tools maintained in a high state of efficiency and under the control of highly skilled machine setters, equipped with measuring and, in some cases, automatic control devices of the type described in the Paper.

If, after taking all possible care in the control of the manufacturing process, it is found that independent final inspection is desirable, this can usually be carried out most effectively by some form of mechanised final inspection equipment. Two typical and highly developed final inspection machines are illustrated in Fig. 30 and 31, and are included as an indication of the type of facilities which are available for final inspection when this is required.

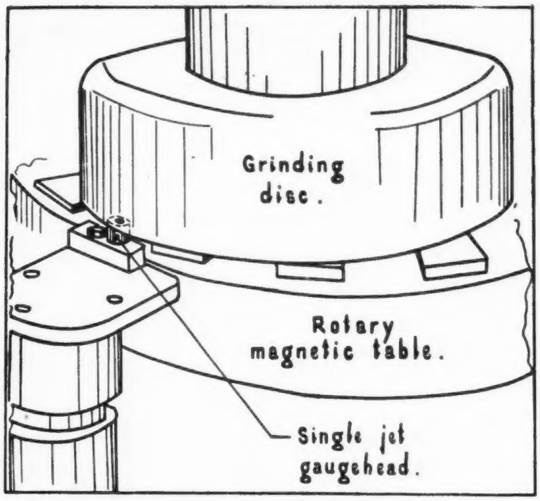


Fig. 28. Arrangement of measuring unit designed to control position of segmental-type grinding wheel on large surface grinder.

(Figs. 30 and 31 appear overleaf)

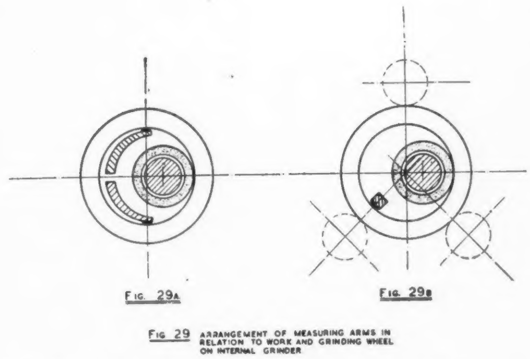


Fig. 29. Alternative arrangements of measuring contacts used on internal grinding machine.

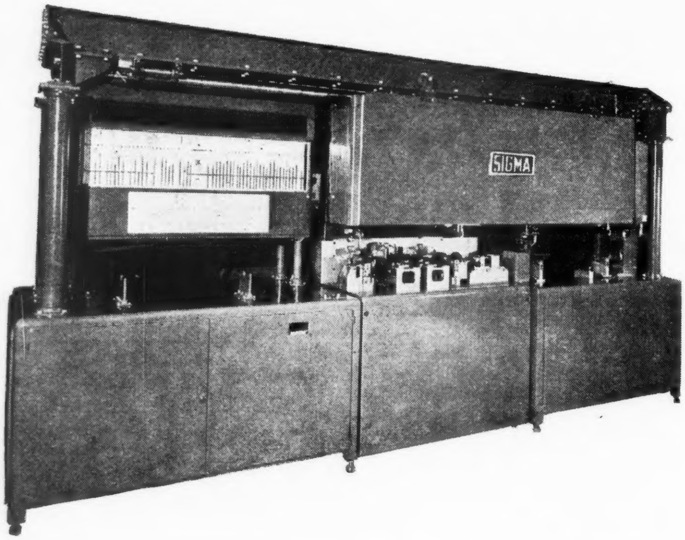


Fig. 30. Final inspection machine making 27 static and 29 kinematic checks on crankshaft and issuing punched card indicating dimensions in error on all reject components.

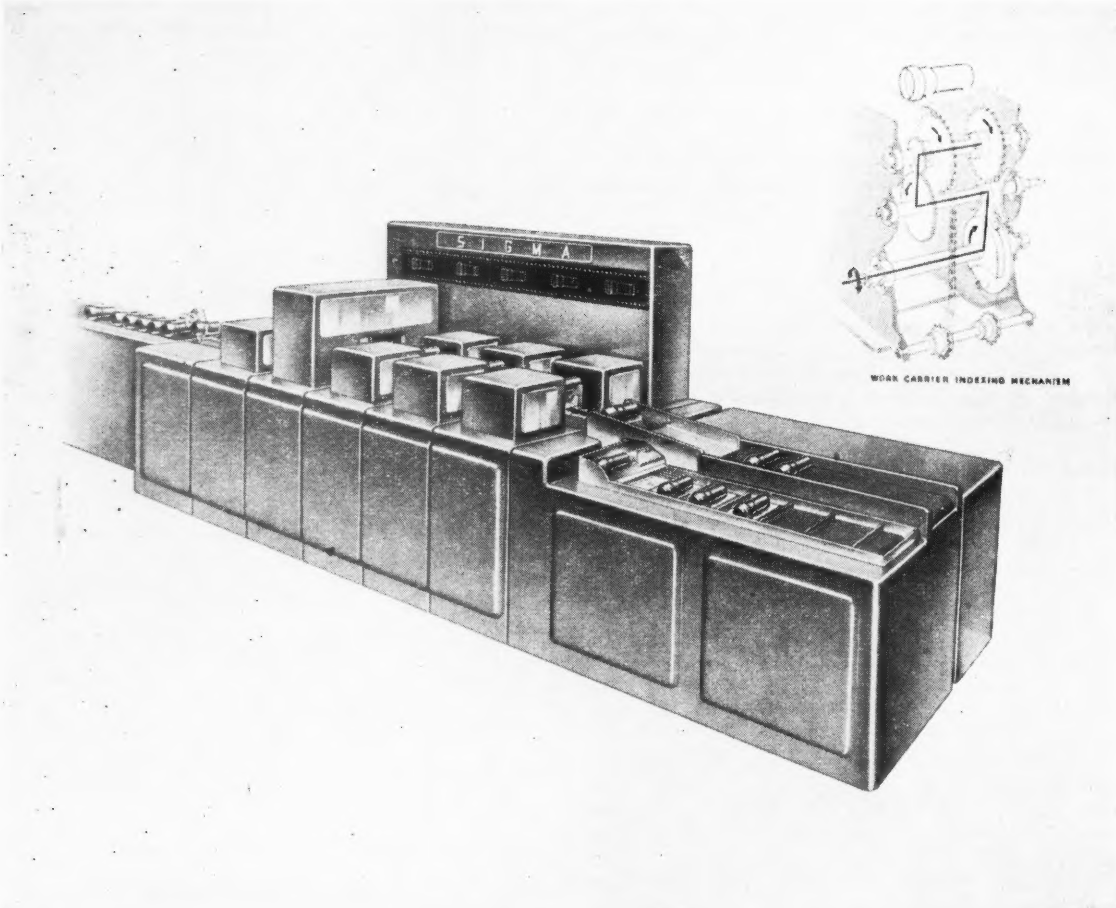


Fig. 31. Multi-dimension transfer type inspection machine inspecting 59 dimensions on a complex part, and issuing punched card on which is recorded the measured size of each inspected dimension.

THE CHALLENGE OF THE "DIP.TECH."

by Sir WALTER PUCKEY,

M.I.Prod.E., F.I.I.A.

Sir Walter Puckey, who is a Past President of the Institution, is a member of the National Council for Technological Awards, and Chairman of the Board of Studies in Engineering.

Sir Walter is on the Board of the British Tabulating Machine Company Ltd. (Hollerith); English Numbering Machines Ltd.; Everett Edgcumbe & Company Ltd.; Bristol Repetition Ltd.; Black & Decker Ltd.; and is Chairman of Automation Consultants and Associates Ltd., and Management Selection Ltd.

He is a member of Council of the British Institute of Management, a past member of Council of the British Productivity Council, and an independent member of the Postmaster-General's Television Advisory Committee.

AUTOMATIC production — what an exciting possibility, and how convenient to produce goods without the difficult and embarrassing presence of workers! This line of argument was long ago rejected by all serious people, and if traces of it remain it is only because we, the executives of industry, have neglected fully to demonstrate that people will be an even more essential part of tomorrow's production programmes. This truth emerged clearly from our Margate Conference and has been spoken from many platforms since. It needs constantly to be repeated and those who have organised this Conference have in their wisdom decided to provide you with a balanced diet, what tomorrow's machines can do and the importance of tomorrow's managers and men.

To talk about people in an age of automation is not, perhaps, to choose as spectacular a subject as others on this programme. To talk about tomorrow more than today is even less popular as managers are not, in my particular experience, long-sighted. However, education is fashionable today and altogether I required little pressure to prepare a Paper which links automation to education, production to people, present to future.

About June, 1958, Birmingham College of Technology will make history by conducting the first final examinations for the award of Diploma in Technology (Engineering). During the following two or three years, probably 20 or more approved technical colleges will be preparing students for similar examinations in engineering and other technologies, leading to the same award. This award will represent a milestone in British technical education, and will be a tribute to the thousands who have helped to build a better road into Britain's technological future.

The Diploma in Technology Award, administered by the National Council for Technological Awards, under the chairmanship of Lord Hives, will be an industrial passport for increasing numbers of promising young men, who have just completed a four or five years' course (usually sandwich) at good university standards. They will, we hope, be graduates with a difference. But how different will they be from the B.Sc.'s of London, Manchester and Durham? And how different will be the jobs they fill, or their subsequent careers? This Paper is an attempt to examine the Diploma in Technology in greater detail than my recent contribution to the Journal of the

Institution, and to relate it to some of the problems these young graduates will face in, say, 10 years' time, when they really begin to give back to their firms, families and fellows, a significant amount of what will have been educated into them during their formative period.

Any educational programme must have its sights set some years ahead, because the first, say, 15 years of educational life lay the foundations of an active life which might exist for another 60 - 70 years. In approving the Diploma in Technology courses, the Council has, therefore, tried hard to visualise the sort of conditions which will exist when the student reaches an age where he is likely to have control of those conditions. What are they ? A glance over the titles of the Papers presented at all conferences on automation held this year might convince you that no managers will be clever enough to control tomorrow's businesses. Many of us temper our regret at nearing retirement with our relief that we have lived only through the relatively peaceful period of two World Wars and one major slump. We feel sorry for our successors, but we have the inescapable duty of training them to be even more effective than we ever were, even if only to ensure that there will be enough profits earned to pay our pensions.

We stand, technically, at an important junction, with many roads leading us by devious routes into the future. It is possible by taking a synoptic view to discern the general direction, at least to select a certain number of essential things required to be recognised by us, now, if our management succession is to be assured. Let me mention some of the most important.

(a) The increasing status of technology

The advertising columns, the research programmes, the invasion of new territories by new machines, the industrialisation of less developed countries, all contribute to a feeling that the world will increasingly rely on technologists. More and better practitioners will only emerge if we reorganise and intensify our education plans.

(b) The increasing status of technical colleges

The technical colleges must bear the brunt of such an intensified programme, and the ambitious plans now in hand must be carried forward with vigour. These plans include the provision of vast expenditures on buildings, equipment, staff, and amenities, but the most important consideration of all is to raise the status of technical college education to a much higher level than has so far been accomplished. It is not only the most important expansion of all, but the most difficult to achieve.

(c) The rapid utilisation of technical knowledge

Britain has often been accused of resting on her research laurels. Today we possess, generally, more knowledge than we use, and research activities may well increase the backlog. Tomorrow's technologists and managers must not only produce new knowledge, but more new goods embodying new knowledge, and this ability to translate theory into practice more effectively is a quality which must be taught by new educational methods. Already in industry new methods are arising which herald tomorrow's standard technologies, and new equipment is becoming available which will assist men to organise more effectively for improved performance. Consider, for example, operational research, which is likely to involve the greater use of integrated teams, crossing departmental barriers and carrying out wide surveys. Consider the growth, too, of new systems of communication, internal and external, which will call for different patterns of organisation and personal relationships. Consider the growth of new specialisms, of which nucleonics and cybernetics are but two specimens, and then realise that the greater the number of specialists, the very much greater problem there arises of integrating their uncommon tasks into a common goal. These, taken together, will call for many new skills, which colleges and companies must recognise and plan to provide.

(d) The need to maintain balance

Unless we want to be involved in even more prolonged arguments between the 'arts' and the 'sciences' we must plan to maintain balance in a rapidly accelerating technical environment. Man does not live by engineering alone and "reaching an understanding with the universe" is a desirable aim for every technologist. To hear the partisan arguments you would imagine that philosophers and technologists had nothing in common, and there will always be the extremists who bear out this statement. But in the common market area are to be found many philosophers who realise that it is difficult to remain philosophic on, say, a plane trip where there is a feeling that a wing might fall off ; and also to be found are many technologists who realise that their real success must depend on broader considerations than a narrow specialism.

The new Award

With these important considerations in mind, let us now turn again to the Diploma in Technology and study those requirements which the National Council has decided that every college must meet, whether the courses are designed for chemists or engineers. I, personally, have isolated five such requirements ; what are they ?

1. The status of the Award.
2. The facilities of the college.
3. The emphasis on 'Projects'.
4. The integration of theory and practice.
5. The liberal approach.

I will discuss these important requirements in greater detail, because individually and collectively they anticipate future demands on the successful graduates when they reach, as I have said, positions of managerial responsibilty, and must help to solve some of the problems I discussed earlier.

(1) The status of the Award

University status has long represented the ultimate educational standard in Britain, and technical college standards are usually assumed to be a few grades

lower even than those of our 'red brick' universities. The fact that a large percentage of Britain's industrial managers are products of technical colleges is a compliment to the latter, but many good men might be even better if they had had the benefit of university standard education. Each of us should be educated to the limit of his intelligence. Some are educated beyond it, and are thereafter called 'highbrow'.

It is easy, too easy, to define universities as those establishments which produce the thinkers, the intelligentsia, the basic researchers and, of course, that large group whose classical studies enable them — in their own words — to maintain a balanced philosophic existence despite the encroachment of the technologists. I am tired of those so-called classical graduates who take obvious pride in telling me that they don't understand what it (I mean technology) is all about. Neither do I, but I don't boast about it. I try to find out.

It is easy, also, to define technical colleges as establishments where *technicians* are turned out, and where in the evenings adult do-it-yourself handicraft courses abound. The fact is that many first-class potential managers, researchers and technologists are on the staff and are produced by both universities and colleges.

However, we must not blind ourselves to the fact that, generally, technical college standards of academic discipline, staff and equipment are not yet up to normal university levels, and with university expansion limited, and with technical demands becoming very great, we must turn to the college for the more and better technologists. They and the universities are both essential and are left and right hands of the senior body educational.

No group can be better than the standards it sets itself. The external London B.Sc. and some of the college diplomas are high in status, but they have disadvantages. The first has been a target for many very good chaps, but let us be frank, it is relatively losing ground. The individual college diplomas are, with few exceptions, not acceptable as national currency and suffer accordingly in status.

So, therefore, with the problem confronting the nation of encouraging more worthwhile candidates towards the technical colleges, it was decided that a new Award, having national currency, and comparable to Honours University standard (as far as one can define such a standard) should be created. This is the Diploma in Technology, the Dip.Tech., or for engineers only, Dip.Tech.(Eng.).

In the 13 months since the Award was announced by the National Council, it can be said to have commenced favourably to inject itself into the national consciousness, with nine colleges and 36 courses already approved. But we would be in a fool's paradise if we assumed that anything less than a period of years would be needed to convince parents, students, the lay public, and many university staff that this Award is indeed up to such a comparable standard. By our deeds we must be known and respected, and our Dip.Tech. deeds are more potential than actual.

Here then, as a high status national Award, is the crest on the cover of the new Technical College Charter. What do we find when we look inside the cover ? Gold leaf binding may hide poor contents within the book, and unfortunately many of our colleges are not yet up to the standard of the Award they seek to administer. College facilities may conveniently be grouped under three main headings, staff, buildings and equipment, and the greatest of these, as always, is staff.

What is the general position of our colleges today? To overcome serious past neglects, the Ministry of Education and the various other authorities concerned are now very conscious of the need for speed in providing better facilities. The programme of spending is a heavy one, and if money was everything we should be doing fine.

(2) The facilities of the college

Staff

Staffing is a serious problem in all educational establishments, including universities, but attempts have certainly been made to increase college teaching salaries, to upgrade certain departments such as Production Engineering and to improve teacher training facilities. But my personal experience, after visiting many colleges, is that many existing staff are overworked, are concerned too much with detail, spend far too many hours in class contact and lecturing and far too little on research and individual project or tutorial work. 'Academic freedom' becomes a joke term under these conditions.

If these conditions are present today, how much worse will they be when, as we hope and expect, more Dip.Tech courses are commenced, enrolling many more undergraduates. It is estimated that the annual output from advanced courses should increase by about 60% in five years, and this, according to a recent report, must involve at least an 80% increase in teaching staff if the latter are to give the right attention to their own and their students' advancement.

We have hardly commenced to consider seriously the ways by which the colleges' customers, that is, industry, can assist the staff shortage. Few things show up your own lack of skill than an attempt to lecture others, and every industrial manager should use "training by teaching" as a means of improving his own senior men. I don't wish to withhold admiration for the thousands of part-time college teachers, but we need to set higher standards in line with the new Award itself. This might involve greater periods of time being given to college work by senior industrial men, and certainly, with the growth of sandwich courses, a close understanding between college staff and the managements of associated industry. As a particular problem, the staff shortage in Production Engineering is even more serious. Out of our total membership probably less than 2% are on the staff of colleges and universities, a percentage far lower than that prevailing in other disciplines. This is easily explainable. Production Engineering is compounded of many relatively new techniques ; it has, so far, a considerable element of 'art' (or

perhaps artfulness) in its practice, and it has therefore failed to attract to itself enough disciplined study of university standard. Actually, in its modern sense, it has as much, if not more potential interest and value than most of the established disciplines, a situation which many senior educationalists are now realising. Certainly, of all the specialist engineering courses covered by the Dip.Tech.(Eng.) it requires the most attention to overcome the staff problem.

I must make one final comment about staff. Many colleges run Management Courses, but the college organisational staff structure often doesn't represent good management practice. College principals are, after all, college managers and should be chosen as much for their managerial skills as their educational qualifications. It has been interesting to observe how some principals consult their staff much more than others, how some delegate certain duties in good managerial style, and how some are much more conscious of the need to remove less skilled routine jobs from themselves and their senior staff than others. If we are to teach management we must effectively practise it.

Buildings

Many of our technical colleges share with certain businesses the doubtful distinction of looking like a hang-over from the last century. Industry has brightened its facade greatly and I, for one, believe that a modern programme requires a modern setting. £50,000,000 or more have been spent on college expansions since the War, and those who, like myself, have visited many of our colleges, will have seen the magnificant marble halls which are now coming into use. The contrast between the old and new in cities such as Birmingham, Nottingham and Salford have to be seen to be believed.

Within the buildings we expect to find far better facilities for staff and students. If we expect the staff to engage in more research, we must give them more privacy and better facilities. Again, project work or tutorial discussions require more small private areas where staff and students may collaborate. Today we see relatively few students engaged in private study, mostly in the library ; many more will be engaged in such activities and they must have much better facilities than are at present available.

Equipment

The third of the trinity is equipment, and here we really have little excuse for the present position. Some of the equipment I have seen in college laboratories is very poor and yet occasionally such high standards exist that one wonders why the others allowed their own standards to slip. I suppose the answer is that individual college standards vary quite as much as individual companies, which is a great deal, and the answer is usually found in the quality of the management. Some colleges seem to have established a much closer relationship with local companies than others, and have been most successful in borrowing(?) equipment. Oddly enough, colleges which have over the years established a reputation for a certain technology don't always have the facilities which back it up. They remind one of certain companies who have rested too long on their laurels.

One would naturally expect the newer departments such as Electronics to possess the best equipment. The disturbing thing to me has been the relatively low standard of Mechanical Engineering departments, and it may be because this department is one of the oldest of the laurel-resters. We have constantly to remind ourselves that more and better electronic, chemical and nuclear engineers must be backed up by even better mechanical engineers, and the Mechanical Engineering department must play a more important part in the college. Its standards are at present generally too low.

The Production Engineering departments are patchy. In some colleges the standards really sink to what could be described as workshop level ; in others they rise to machine-tool laboratory level. One realises that a well-equipped production laboratory can be very costly, but you can go only so far on the cheap, and the Ministry and colleges seem now to recognise the need for more comprehensive equipment, capable of being used much more on the many research and project jobs that more disciplined study will reveal. I imagine that when, as is the general plan, less advanced work is removed to supporting colleges, the senior colleges will be able to concentrate more fully on senior work, using better equipment.

Corporate activities of staff and students

Before I leave facilities, I would like to comment on certain other requirements of the Council. We believe that inter-departmental barriers should be broken down as early as possible — between staff and between students. An advanced technical college may well tend, unless it is very careful, to become a specialist organisation, narrowing rather than widening the outlook of those living and working within it. The true education must encourage a liberal attitude, which will be more difficult to maintain as specialisation increases. In any case, modern technology will require much better communication between the specialists and, therefore, staff and students for two good reasons must be encouraged to communicate. This can be helped by hostel living, which approximates to good (but not always achieved) university standards. It can be helped by active student unions and by full participation by staff in professional activities. This Institution is fortunate in having some members who use the colleges in this way. We should have more.

(3) The emphasis on 'Projects'

What is a project and why do we think it is an important modern educational tool ? I believe there are at least four good reasons :

1. Its completion is likely to involve several departments or specialisms, and will encourage communication between staff and students.
2. It encourages a 'do-it-yourself' attitude in the student, that is, an ability to 'do' as well as 'think'.

3. If correctly planned, it will encourage the student to use knowledge which he has acquired during the course, and which he may not be examined in. I refer, of course, to the so-called liberal studies, such as Economics and Human Relations.
4. The project can become a first-class link between college and works activities. I hope that many of the 'projects' will require sustained action through the *whole* period of education and not only the college portion. The project can then act as a catalyst.

I have still not given any examples of good projects. So far, few colleges have given detailed thought to this matter, and the field is wide open and affords tremendous scope. Some colleges are thinking at present more of 'design' projects than those which satisfy the four requirements mentioned earlier. I hope they will remember that plenty of people can design or plan very well indeed, but fewer can carry a plan or design through on time to a successful conclusion. This ability is one which is of great value to industry and should be constantly encouraged.

(4) The integration of theory and practice

I have already written about this problem in the Institution's Journal, and right away I should say that this special feature of the Dip.Tech. is still largely unresolved as a practical exercise. This may seem odd when you realise that, according to Mr. A. A. Part, Parliamentary Under-Secretary, Ministry of Education, there are now 173 'sandwich' courses operating in the country. All I can say is that so far, few appear to be up to the new standard we require, or, if they are, the colleges aren't very good at telling us how theory and practice are integrated. Colleges are approaching this requirement in a variety of ways, all designed to keep the student in touch with the college during the works period. So far, I'm delighted to say, sandwich courses dominate the Dip.Tech. scene and out of the 36 courses so far approved, 80% are planned on a four or five year sandwich basis, with approximately equal alternating periods of five to six months each in college and works. In a number of cases, the works base may vary geographically over the complete period because the company desires to move the undergraduate around to various works.

It is fairly easy to make it obligatory for students to report back to college one evening each week during the works period, to prepare essays on a correspondence basis, or to do some required reading. It is also easy to request a periodic report from, say, the training supervisor of the company on the progress made in the works period. It is not quite so easy, because of shortages, for college staff to visit the works regularly and to cross-examine the young hopefuls ; some colleges have, however, decided on this method, which is a good one.

Most of this is at present theory because relatively few Dip.Tech. courses are yet fully operative. I don't believe that the integration of theory and practice is yet worked out and as much remains to be done by companies as by colleges. I, personally, hold the view that the whole period of, say, four years should be regarded as one of continuous education and, therefore, the recognised educational body, i.e. the college, should have charge of the undergraduate during that full period, lending him out, as it were, to the works for certain periods. This may seem unattractive to those companies who are paying for the chaps who are being lent back to them, but experience tells me that I should generally trust the college more than the company on educational matters.

Is this a slur on many of the first-class educational officers of industry ? I certainly don't intend it to be, but I emphatically say that speaking of industry *generally*, education to the standards that we are *expecting* from the colleges is just not given. I would, therefore, expect college principals to take the initiative in collaborating with, criticising if necessary, and assisting their industrial opposite numbers to a greater extent than they seem, or are inclined, to do.

(5) The liberal approach

A definition of this has been harder to reach within the National Council than almost any other requirement. It has been difficult to define qualitatively and quantitatively. Some authorities have said that up to 20% of total formal college hours should be given to liberal studies, while at the other extreme some colleges try to get away with no more than about 2%.

Perhaps we are asking too much too quickly. Technical colleges have long had a tradition of hard work and long hours of student/teacher contact on technical subjects. In recent years semi-liberal subjects, such as industrial administration, human relations and report writing have found their way into many college programmes, even if less quickly into formal courses for H.N.C.'s, B.Sc.'s, or college diplomas. These subjects have been largely extra-mural and post-graduate. Now we ask that a quite considerable percentage of course hours are devoted to formal presentation of liberal subjects, while expecting at the same time to reach honours level in the technical subjects. Can we, in less hours, tell the students how to bake and enjoy the cake too ?

What are liberal subjects ? The Ministry of Education suggests, *inter alia*, the following :

Human Relations
English and the Art of Communication
Economics
Evolution of Industry
Music, Art, International Affairs
Physical Education

There are occasions when I ruefully smile at our earnest attempts to surround a precise formal course with a liberal atmosphere. The older universities have created over hundreds of years such an atmosphere, even if in more recent years conditions have seriously deteriorated owing to lack of accommodation and staff. To expect most technical colleges quickly to create such a rarefied ambient setting is asking a lot.

However, all things are possible, given time and enthusiasm, and they are all trying hard. In practice, attempts are being made to encourage a liberal setting to the technical studies, by giving more time and attention to formal and informal liberal activities. *Formally*, colleges are planning for an average of about 10% of class hours on some of the liberal studies I have mentioned earlier. No attempt has been made by the National Council to standardise a college approach to liberal studies beyond ensuring that the importance of the idea is recognised, and that certain minimum activities are planned.

Informally, many colleges already have Students' Unions and other such activities. They help students (and staff) to free themselves from the narrow environment of a technical specialism and to realise constantly that their success, as technologists and as men, depends also on wider considerations and understandings.

Quite apart from formal tuition of certain 'liberal' subjects, and informal encouragement of informal activities, there remains the very important business of creating a 'liberal' atmosphere in the technical college. It is a similar problem to that faced by every industrial manager. Some companies are at any given time very efficient, but have little soul; the managers don't think with their hearts. Others manage to create an atmosphere of efficiency *and* mutual understanding by a variety of techniques and devices. College principals vary as much as industrial managers in their managerial qualities, but we have found generally a very real willingness to look at the National Diploma as one of the best opportunities likely to be presented for increasing the stature of the colleges. I am sure that the better conditions, the higher status, the greater interest of the public in technical education, and the needs of the future are all on the side of a college renaissance.

The challenge to Institution and industry

Finally, may I, as a critic, restore balance by saying again that the college renaissance will be possible only if the customers give far more attention to technical training than we have already given. You, Mr. Chairman, have laboured long as Chairman of the Institution's Education Committee to modernise our own outlook and you are not complacent. Members of the Institution in their business spheres must carry more responsibility for individual programmes collaborating as never before with the colleges. In particular, we have, I believe five tasks to perform in order to meet the Dip.Tech. challenge:

First We must more actively support the national educational programmes.

Second We must work more closely with the colleges.

Third We must release more good men to the colleges for teaching and receive more good college men for industrial refresher experience.

Fourth We must support more post-graduate courses with the full realisation that education is a continuing necessity.

Fifth We must use and conserve skill wisely, realising that in the long run it is Britain's greatest asset, and will bring to us, as interest on our tremendous investment, the greatest return of all.

"BEER" — a Case Study (concluded from page 733)

and delivery methods necessitating this arrangement.

Bulk tank wagons for grain have recently proved practicable and the number in service is increasing. This method of delivery benefits both brewer and maltster and work has started on arrangements to accommodate it.

Road tank wagons will discharge into a divided reinforced concrete hopper having a total capacity of 15 tons of malt. The grain will run out of the hopper by gravity into the boot of a chain link elevator which will discharge into a chain link conveyor commanding the intake hoppers on the existing treatment plant.

Rail tank wagons will discharge into another hopper from which the grain will also reach the existing intake hoppers *via* the elevator and the new chain link conveyor.

The electrical gear will incorporate sequence interlocks and, like the existing plant, will be push-button controlled.

The new system will eliminate manhandling once the grain reaches Park Royal, labour then being required merely to supervise the plant. It will, therefore, enable grain to be taken in at night when necessary without additional labour and also shorten the wagon turn-round time.

It is expected that the cost of the new system will be recovered within five years.

Bottling

Of the many operations carried out before Guinness reaches the consumer, bottling is probably the one that approaches most nearly the production engineering field. However, as Guinness is produced exclusively for sale in bulk and is mainly bottled elsewhere by others, first-hand experience of bottling is at Park Royal limited to a small experimental plant installed for the study and understanding of any difficulties or problems that may arise during the bottling stage. What has been done by this side of the industry is, therefore, not dealt with here.

Whilst the brewing industry cannot hope to match the advances made in the production engineering field, the adoption of new methods, materials and plant and the improvement of those already in use is constantly under consideration as it is hoped this study has indicated.

Acknowledgment

The author wishes to thank the Directors of Messrs. Arthur Guinness, Son & Co. (Park Royal) Ltd. for permission to publish this Study.

"BREAD" – A STUDY IN PROGRESSIVE AUTOMATION DEVELOPMENT

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Summary ·

1. MAIN OBJECTIVES

The problems which face a Board of Directors when wishing to advance the technological means are great. It is vital to take an overall company point of view: (1) Sales, (2) Production, (3) Finance, and the combination of all three, (4) Growth Policy.

2. OPERATIONAL RESEARCH

It is vital that a company should have an operational research policy and team. Their own team can be aided valuably by outside specialists and consultants who can bring to bear a very wide range of experience from quite different industries. Objective facts then discovered must be assessed against their economic implications. They must be carefully weighed bearing all the above four points in mind.

3. CHOICE OF CORRECT APPROACH

Having obtained sufficient facts, management must have sufficient courage to act quickly and adopt a short as well as a long term development and re-equipment policy. One must be conscious that facts of today are not necessarily true of a remote tomorrow and thus the choice of approach should always favour the method and plant having maximum flexibility. Also the operational research team must continue to function and keep gathering facts, its policy being steered by the results of market research and overall concepts of the Board.

4. SERVICEABILITY AND MAINTAINING THE PLANT

Having chosen as my case study automatic bakeries, these illustrate some most valuable lessons. For instance, one should choose equipment which is easy to service; interchangeable tropicalised control and motor units should be adopted, requiring minimum attention. Encapsulated plug-in units which remove the need for scientific trouble-shooting should be preferred. Means of self-maintenance, e.g. self-lubricating bearings, temperature-compensated equipment, self-cleaning by compressed air blasts, etc., are the kind of facilities that must be planned into automated plants. They should be located in very easily 'get-at-able' places on the plant. The main factor which must be kept in mind is that there must be three shifts working with minimum shut-down time to obtain the full benefits of automation.

IT is sometimes difficult for production engineers to appreciate the vast field in which automation can function to increase productivity per man, productivity per £ investment on plant, and generally to increase customer satisfaction, i.e. serve to benefit human welfare. Normally, production engineers think only in terms of what happens on the factory shop floor. There are, however, many other types of productive activity which function in this country where the article is completely different from what engineers normally think of as a product.

The bakery industry is a good example in which a great deal of quite advanced mechanisation has taken place during the last few decades in the production of bread. There is a distinct trend towards a certain degree of automation.

The modern semi-automatic bakery has very few productive people visible at any one time, but since it functions over three normal shifts during six days per week, and has a weekly overall maintenance staff, there are in fact quite a number of human employees concerned with it. The main characteristic of such a modern bread-making establishment is that the productivity per man has increased to the extent that now by far the largest component of the cost structure of a loaf

of bread is the cost of its ingredients. The cost of baking, i.e. expenditure on fuel and plant, etc., is a smaller factor than it was in the non-automated days, and the human content in the price structure is the smallest that it has ever been. Viewed from the overall point of view of human society, it will be agreed that this is as it should be, i.e. that the price to the ultimate customer consists mainly of the cost of the ingredients.

Generally in many industrial concerns, at Board level discussions, it has often been thought that the investment required to automate plants is disproportionately high to the returns obtained in production, and this has given rise to hesitance in adopting machinery employing the most modern techniques. This, however, is not true so far as the bakery industry is concerned. Here, apart from the fact that the production from any one plant lies between 50,000 and 100,000 loaves of bread per day, we have in addition a most flexible production unit capable of producing loaves of different sizes, different consistency, and of various ingredient structures and qualities. The automation of such plants has been gradual and the write-off period of any one development phase is usually two years or less.

Present day mechanisation

For production engineers not familiar with a modern bakery, it may be useful to follow through the brief description of the bakery procedure. There are many interesting lessons to be learned relating to other industries.

The normal trend in mechanising the production of loaves has been concentrated on carrying out by mechanical means the operations traditionally done by the housewife in the kitchen several centuries ago. The actual individual periods between operations have been governed solely by the growing time of the yeast bacteria, just as they were in the housewife's kitchen.

Sequence of procedure

(a) Thus we have seen the development during the past decade or so of many automatic blending and mixing machines for flour and water, yeast, etc., operating on a batch process system, the batch being about 2 cwt. We have also seen the more accurate control by weight of the ingredients, but essentially still retaining human supervision.

(b) Following the mixing there is a waiting period of about an hour or so, permitting the yeast bacteria fermentation to commence.

(c) This is followed again by a batch process of re-mixing the partially fermented dough with a few additional ingredients for improving the flavour of the product. By experience it has been found that it is better to mix these items (such as salt) at a later stage. The process also drives out the carbon dioxide gas produced by the initial colonies of yeast bacteria.

(d) This is followed by another period of fermentation over some two hours, permitting the dough to develop many of its required properties which are needed to give a properly distributed bubbly texture for bread as we generally know it in the West (i.e. leavened bread).

(e) After this prearranged dough growing period, the time has arrived to subdivide the large mass of dough into individual lumps which will later represent a specified loaf. This is accomplished by a modern dough dividing machine which in many respects is similar to a die casting machine (Fig. 1). In other words, it operates on a standard volume basis. The dough is fed into a large hopper from where it is pressure injected into a rectangular cavity having its top and bottom walls in the form of large platform shaped knives, which are operated by

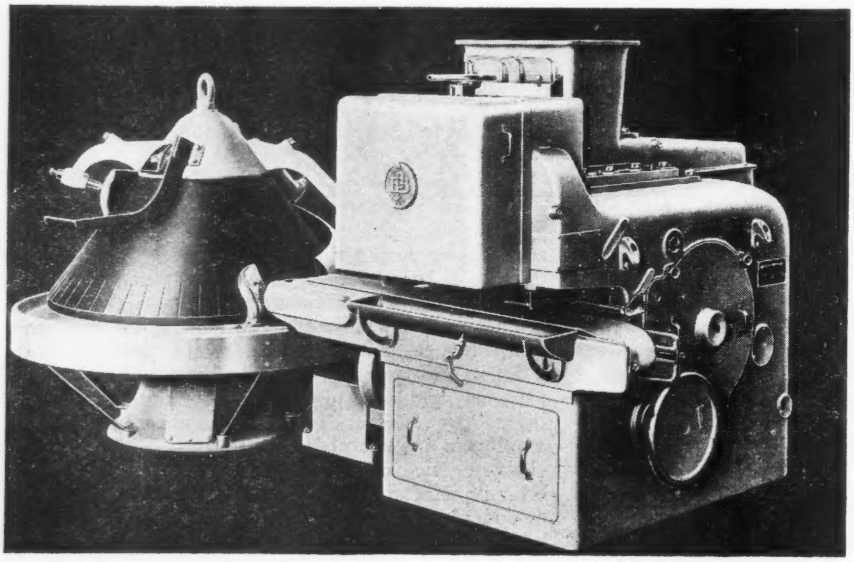

Fig. 1. Dough divider and conical dough ball producing equipment. Divider works on a volumetric principle.

(Courtesy: Baker-Perkins Ltd.)

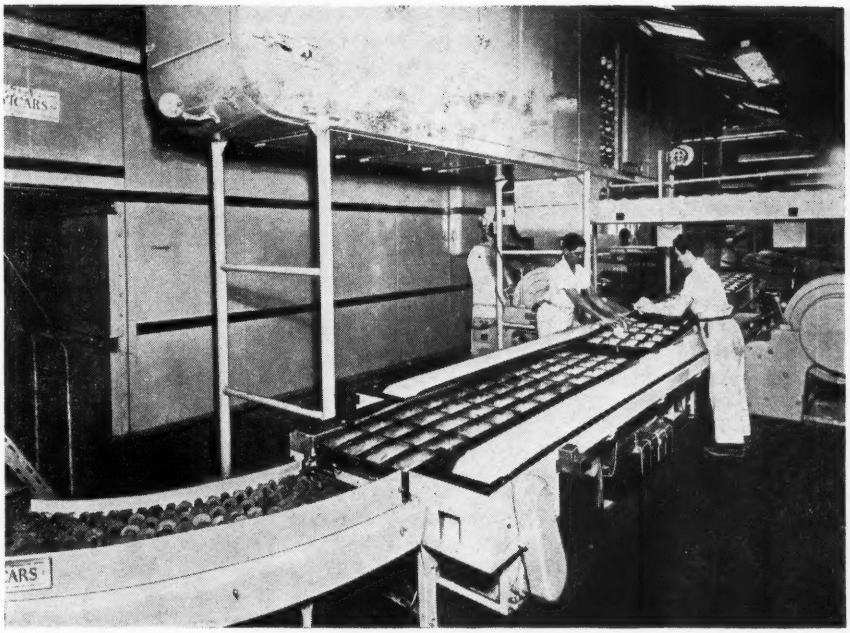

Fig. 2. Two operators insert the twisted dough pieces into quadruple rows of baking tins

(*Courtesy*:
T. & T. Vicars Ltd.)

cams. The other four walls of the cavity are also movable by similar cam actuation at a later stage of the cycle. The operation briefly is that the top knife-plate moves away exposing the rectangular cavity, the dough flows into it under pressure and then the top knife cuts off the dough, closing the cavity. The bottom knife-blade now opens, whereupon the other walls of the cavity close up, ejecting a lump of dough on to a band conveyor located immediately beneath. The bottom blade now cuts off the residual flash of dough. The cavity now re-opens to its full size, whereupon the top knife platform moves out of position, re-exposing the top opening for the next dough piece to flow in, and so on in sequence.

(f) The roughly brick-shaped dough pieces moving forward on the band-like conveyor are now passed into a so-called "conical-hander" machine which rolls the brick-shaped dough pieces into balls.

(g) These balls then roll into a mechanical flap diverter device which puts them into the pockets of a multi-platform type conveyor running fairly slowly through a long tunnel. This provides a climatic treatment, the machine being known in the bakery as a "Prover". The dough balls in the pockets now progress on the conveyor within an accurate temperature and humidity controlled environment. The conveyor is made long enough to allow the dough balls to remain in this condition for about one hour, thus permitting the colonies of yeast bacteria to bring forward their life cycle and increase the size of gas bubbles. These produce the improved texture of bread now generally regarded as essential. Without this so-called Prover action bread would be cloddy and doughy, and certainly not up to modern customers' expectations.

(h) After emerging from the Prover the dough balls are pushed through a "mangle-like" machine and the dough pieces are rolled into sausage shapes having lost most of the trapped gas. This operation further improves the texture of the dough.

(i) After this, the sausage-like dough pieces are manually placed into rectangular baking tins moving forward on a horizontal conveyor towards the oven. Some types of loaves consist of two of these sausages wound together in a spiral manner, which causes the residual gas bubbles in the dough to become elongated with further improvement in the texture of the loaf. We thus have the final charge in the rectangular tins in the form of a double twist, giving a somewhat knobbly appearance ultimately on the surface of the bread (Fig. 2).

(j) The charged tins, marshalled in rows of 10 or 12 or more, now advance on broad conveyors quite slowly into long tunnel ovens in which the baking temperature progressively rises as the tins move forward, until approximately one hour later the fully baked loaf emerges at a quite high temperature (Fig. 3). In modern tunnel ovens accurate temperature control of each stage is maintained throughout, in many cases by electronic means. It is essential to avoid too rapid baking, as the crust would become badly cracked and disfigured. Thus, after considerable experience, a series of accurately controlled temperature steps have been arrived at, utilising a combination of convection heating and radiation heating. Great care has been taken

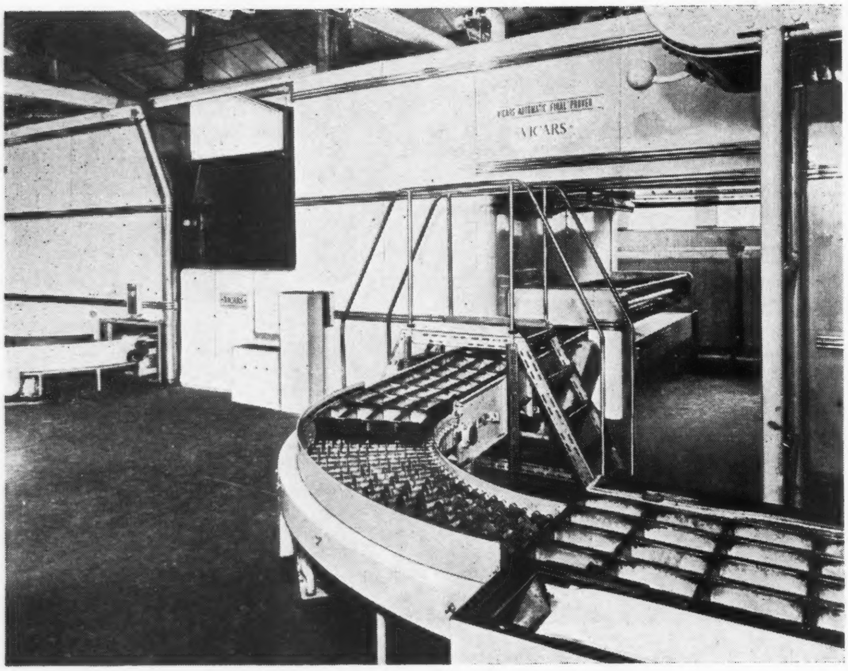

Fig. 3. Automatic prover loader *(right centre)* and automatic prover to oven transfer loader *(left centre)* approximately one hour later; and automatic oven unloader *(extreme left)* approximately a further 45 minutes later. Note that no human intervention is required.

(*Courtesy*: *T. & T. Vicars Ltd.*)

in the design of modern tunnel ovens to obtain the greatest possible uniformity of temperature distribution over the total oven cross-section at right angles to the direction of movement of the conveyor, to produce uniform baking.

(k) The emerging loaves in their tins are now discharged, in older bakeries usually by men equipped with asbestos gloves, but in the more modern examples of semi-automatic bakeries by special tin unloading machines. These liberate men from this very unpleasant hot work (Fig. 4).

(l) The loaves, now marshalled in narrower conveyors, move off into the cooling rooms, whilst the tins marshalled on separate conveyors return to the beginning of the tunnel oven, first passing through automatic grease spraying equipment to regrease the tins for use again later.

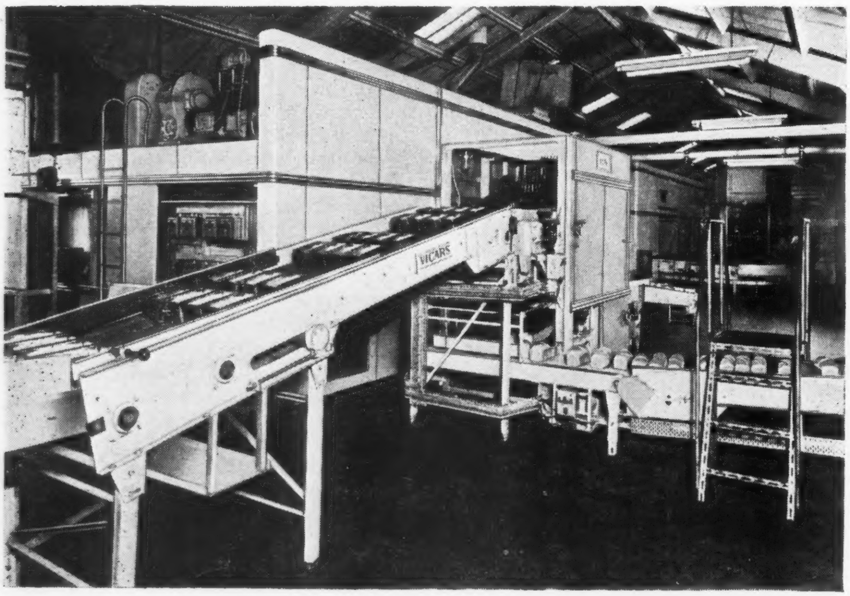

Fig. 4. Automatic de-panning equipment separating hot loaves *(outlet on right)* from tins without human intervention *(outlet on left)*.

(*Courtesy*: *T. & T. Vicars Ltd.*)

(m) The loaves are now placed on trolley racks which contain several hundred loaves in climatically controlled large rooms, and they commence to cool.

(n) After the loaves have cooled sufficiently to have achieved adequate solidity satisfactory for slicing, the loaves are again loaded on to special conveyors which move them forward into multiple loaf slicing machines. These are usually so designed that the individual slices of a loaf are not allowed to fall apart, while the loaf moves forward to the packing stage on the conveyor.

(o) The now clamped sliced loaf is presented to an automatic wrapping machine which wraps greaseproof paper round it and produces a heat sealed envelope. Needless to say, the degree to which this sealing can be considered hermetically effective must be related to the 1 - 2 days' life expected from the wrapped modern loaf.

(p) At a later stage, the loaves are now manually loaded in an orderly manner on vans specially designed to hold a given number, for despatch to the retail distributing shops.

Advance of automation

During the last five years and with accelerating pace during the last two years, many steps have been taken to adopt a more and more automatic approach (other than the simple control devices such as temperature controls referred to above).

There are several advanced designs of automatic handling plant in which operations previously carried out manually are now done by mechanical handling devices, under overall human supervision.

Thus, for instance, we see automatic oil-fired furnaces which react very sensitively to the temperature sensing and controlling equipment. These are able to produce heat at three levels, maximum, medium and just pilot flame conditions, are usually equipped with electronic ignition and flame failure safety control equipment and maintain in each stage of the tunnel-oven its preset temperature (Fig. 5). It is important to realise that if for some reason the oven conveyor is not fully loaded, the local temperature would rise seriously and cause scorching of the loaves in the neighbourhood of this open space area. The more sensitive type of control devices in long tunnel ovens rely on several thermo-couple sensing devices spaced along the axis of the tunnel, each controlling its own zone which mitigates against this difficulty.

More precise humidity control equipment is also used now, usually deriving its "decision" from electronic circuits coupled to the humidity sensing device. This feature is of particular importance with the varying humidity encountered in the British Isles.

There are now many sequential dough piece handling devices in use or rapidly coming into use in modern bakeries, and these considerably reduce the hand toil which the operator of the past had to carry out.

In the interests of hygiene and general appearance improvement, the modern automatic bakery equipment is beginning to resemble more and more the hygienic look of hospital equipment. This not only guarantees cleanliness but by elimination of many lumps of crust, crumbs, chips of dough pieces, etc., which were characteristic of the older type of bakery, ensures that the finished product has the desired shape and appearance. There is a corollary to this shape problem: the automatic slicing and wrapping machines are able to operate with the minimum of trouble and shut-down if the loaves have consistent shape and resilience. Shape control is very largely achieved by the use of modern environment control gear, which is usually electronic. Fig. 6 shows slices obtained from loaves made on older type bakery

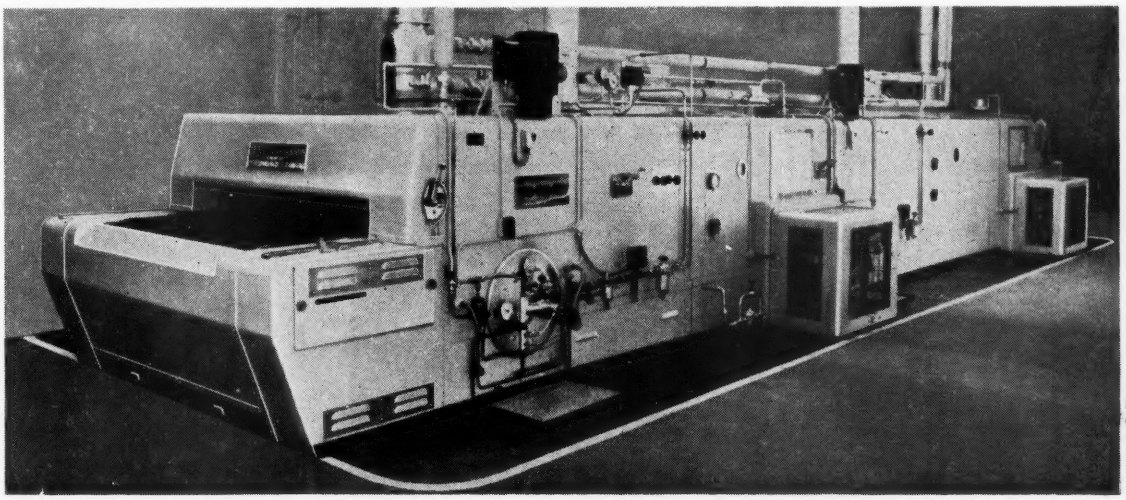

Fig. 5. In-line type tunnel oven. Note that separate heat zones have their own oil-fired burner installation. (*Courtesy: Baker-Perkins Ltd.*)

Fig. 6. Slices of bread produced on older type bakery equipment. Note unequal bubble distribution.

(*Courtesy: Film Surveys Ltd.*)

Fig. 7. Slices of bread produced on more modern bakery equipment. Note more equal bubble distribution. (*Courtesy*: *Film Surveys Ltd.*)

equipment showing considerable inconsistency in texture. This should be compared with Fig. 7 which shows the considerably improved uniformity in texture resulting from advanced modern equipment.

Physics of appearance problems

An interesting approach to the problem of appearance, which was made use of during the War years, when the mixture of ingredients in flour was controlled by Government regulations, was an attempt to improve the " apparent whiteness " of a loaf. It will be appreciated that optically the whiteness of a slice will depend to a large extent on the depth of the individual gas bubble cavities exposed when the slice is cut. If these cavities are large and deep, producing an optical shadow, the whole appearance of the slice will be darker than if the bubbles are small and shallow. One of the extremely clever means of improving the apparent whiteness was the adoption of the technique referred to previously, i.e. of twisting two sausage-like dough pieces together before placing them in the baking tin. This results in the elongation of the gas bubbles, which becomes further accentuated as the twisted dough expands under the baking oven temperature-rise cycle. When such a loaf made of twisted dough pieces is sliced, each gas bubble has a longer appearance than would be the case had the twist not occurred, and the elongation of the gas bubble has its major axis in the plane of the slicing action of the machine. Consequently, when the bread is sliced an apparently shallow but long gas bubble is exposed to light, giving a whiter total apparent reflectivity than is the case with the round bubbles. This is a very interesting way of improving customer satisfaction within Government-controlled bounds of ingredients. It should, of course, be noted that this is not purely a matter of fooling the customer, but of making the best use of a technique which was basically introduced to improve the texture and thus the edibility of the product.

The problem of weight control

Many experiments were carried out during the past decade, particularly in the last five years, to try and improve the consistency and uniformity of weight of each loaf. This has partly been induced by the Weights and Measures Law insisting strictly on a minimum permitted weight, and also by the operation during the War of the bread subsidy. The baking of an excessive weight of loaf then was just as much frowned upon by law as the baking of a loaf too light in weight.

Thus the baker was between the devil and the deep blue sea, since with such a complex physical and biochemical product as a loaf of bread it is just not possible to make every loaf the same weight. Fig. 8 shows the average distribution of weight deviation of loaves of bread from a typical production run in a semi-automatic bakery.

It will be noted that the spread of weight deviation contains a very high percentage of loaves which are either below the legal limit or far above the subsidy limit.

Thus the life of a baker was a continual struggle to improve consistency of weight by the most elaborate human controls all along the production line. None-the-less, due to the fundamental fact that the dough dividing machine works on a volumetric basis, whereas bread is sold by weight, and the fact that dough is a biochemical product resulting from the life cycle of fermentation bacteria, it has not been possible to narrow down appreciably the production spread of weight deviation. It is simply not possible to make each yeast bacteria multiply and live at the same rate just as it is not possible to control, for instance,

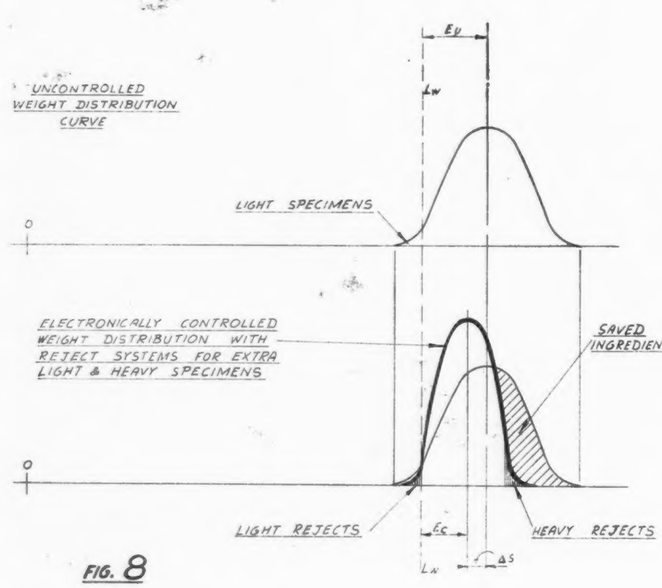

FIG. 8

Fig. 8. Effective spread of weight distribution histogram of uncontrolled dough divider *(top curve)*. Reduced spread of weight distribution of dough pieces *(bottom steep curve)* after combined effect of electronic computer weight control and pass-and-reject gate action eliminating the heavy and light weight dough pieces. Note shift in mean weight and effective saving in material used.

the number of children each human being has. Whereas there is an average statistical distribution, the individual distribution varies considerably.

Experimental equipment for computer-controlled dough divider

At a Paper read to the British Chapter of the British Institute of Bakery Engineers, the author described a series of experiments that were carried out in 1953-54 for one of the largest bakery combines, in an attempt to :-

(i) cast some light on the problem of weight variation; and

(ii) to see if it would be possible to evolve an electronically controlled dough divider to reduce the spread of weight variation.

After considerable analysis and study of weight variations with time during the production cycle immediately preceding and during the dough divider process described above (see section (e)), it was found that the minute-to-minute random variation of dough density (and the resultant dough piece weight) had a spread which was only about half that of the total production spread experienced during a longer period, such as an hour or a day. It was found also that the average dough density varied cyclically with each large dough vat representing about 10 minutes' production. In other words, the dough density was directly related to the fact that dough was produced in a batch-like manner as described earlier. (See section (c)).

The random variation from dough piece to dough piece which is directly attributable to the yeast bacterial action is, of course, still responsible for the resultant spread of about half the total weight previously encountered.

In order to use this short-term narrowing of the spread for longer-term control purposes, a dough dividing machine was modified slightly and equipped with an electric motor controlled screw capable of varying the volume of the rectangular dough divider cavity, by either increasing its volume or decreasing it.

The output from the dough divider, i.e. the emerging dough pieces after they flowed through the conical-hander, were passed through a specially designed high-speed weighing device (Fig. 9). As the emerging dough pieces arrive at approximately 45-50 per minute the time of weighing available is extremely short, and this gives rise to a considerable problem. This was solved by a combination of novel weighing mechanisms and electronic sequential timing at high speed. The actual weighing period was reduced to only 1/5th of a second, the rest of the time between dough pieces being used for handling. Thus 1/5th of a second was allowed for the dough ball to roll into the scale pan and to settle down (' settling time '), the scale pan and scale mechanism being locked during this period.

The weighing mechanism was then unlocked in about 1/100th part of a second and remained unlocked for 1/5th of a second (' weighing time ') : it was then re-locked in 1/100th part of a second. During the weighing time, the scale mechanism moves either upward or downward against a torsion spring pre-set to the desired mean weight of the dough piece. As the weighing period is a predetermined time, the deviation from the centre position of the scale mechanism is directly proportional to the acceleration of the weight of the dough pieces. Thus the excursion of the weighing mechanism in either direction is greatest when the weight deviation from the norm is greatest. In the experimental equipment the scale mechanism was coupled to a deflection sensitive group of photo-electric cells, arranged as a grading system. This could produce in itself a complete histogram of the sequential weights of the individual dough pieces.

After the scale re-locking action referred to above, a scale pan tipping mechanism ejected the dough ball from the scale pan in 1/10th of a second (' tipping time ') and allowed the dough ball to roll further along the production line to the flat mechanism which puts the dough pieces into the Prover conveyor referred to above.

The rest of the interval permits the scale pan to re-index and re-lock and allows for the empty scale pan to await the arrival of the next dough piece.

Simple electronic computer

The method of computing the instantaneous average weight continuously is to feed the weight deviation information obtained from the group of slit photo-cells into a specially designed very simple computer. This is capable of working out the instantaneous average weight of the instantaneous histogram obtained from a pre-set number of dough pieces. For instance, one could pre-set the computer to work out the average weight of 10 or 20 sequential weighings. The average weight information thus obtained continuously is characteristic of a particular relatively small batch of dough, and if this is higher or lower than a pre-set tolerance value, it produces an error signal in the associated electronic circuits which operates the reversible electric motor gear to the screw of the dough divider cavity control.

Thus, compensatory action can be taken automatically as the density of the dough varies, which with a fixed cavity would have resulted in over or underweight loaves. The control decision reduces the size of the cavity when the dough has high density and increases it when the dough density decreases. It will be seen by studying Fig. 8 that with the electronically controlled dough divider, the statistical distribution of dough piece weights is considerably narrower than with the uncontrolled one.

Pass/reject mechanism

In addition to the computer-controlled dough divider, a selective reject gate is also included in the production line immediately after the weighing mechanism. This extracts any individual dough ball which is extra heavy or extra light. This can occur when a very large pocket of air is trapped in a dough divider machine, or alternatively, when an extra high density lump of dough appears. A direct action control on the reject gate selectively picks out these

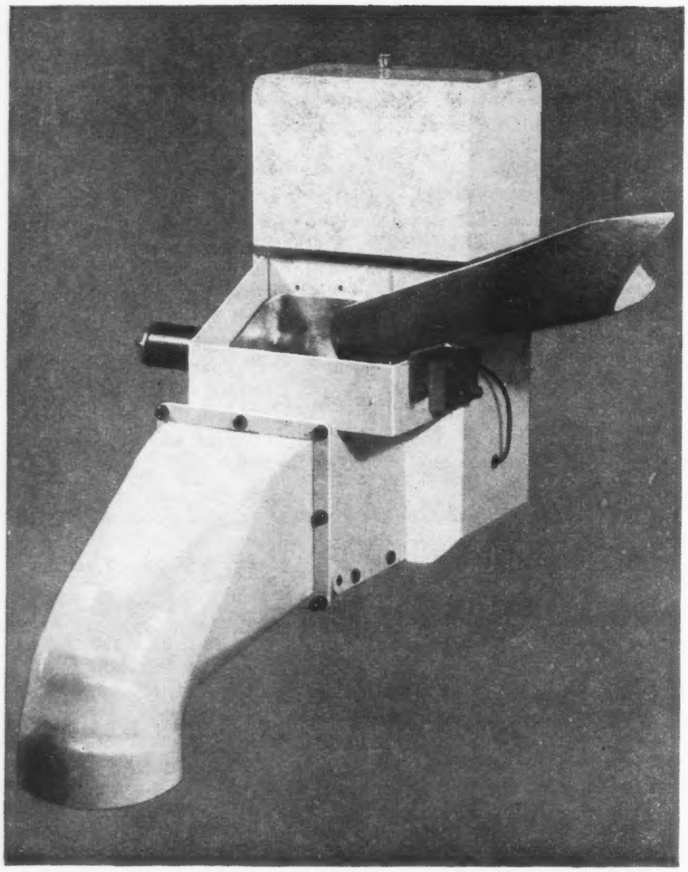

Fig. 9. **High-speed electronic dough ball weighing equipment.**

(Development by: Sargrove Electronics Ltd.)

exceptional dough pieces and allows them to be fed back into the dough divider hopper.

To compensate for the reduced production that this selective rejection would cause, the total production rate of the dough divider was increased by a similar percentage to the average reject percentage. Although this necessitated an increased operating speed for the dough divider, the scale mechanism was able to work at a periodicity of one every second, thus maintaining the same output of dough pieces within the tolerance permitted.

Resultant reduced weight deviation

From the lower half of the histogram (Fig. 8) it is clear that there is a considerably reduced spread in weight deviations when compared with the upper half. Due to the histogram being narrower, the mid-point setting can be shifted slightly nearer to the lower minimum weight limit set by the Weights and Measures Law. Thus, a small saving of the total dough used can be effected. Whilst the saving is small, it is nonetheless a sufficiently high percentage to represent a fund of money enough to pay off the major cost of the additional technical apparatus.

A glimpse into the future

Much operational research has been and is being carried out, some examples only having been described. Several lines of progress are now being followed in the bakery industry :-

(x) There is a general tendency to improve the accuracy of the dough divider and the greater organisation control of dough density.

(y) The development of statistical control devices such as those described in the above experimental paragraph, which by combining electronic, hydraulic or pneumatic means are suitably robust to achieve the narrowing down of the production spread histogram as mentioned above. The reliability in service of such apparatus naturally depends on the excellence of the design and production methods of such apparatus; it is essential that ease of maintenance is built into the design of the equipment from the start.

Maintenance can be greatly simplified by the adoption of interchangeable units so that the local maintenance man deals only with plug-in problems.

(z) Parallel to this development, there is some entirely new rethinking going on in the bakery industry which is much more radical and undoubtedly promises much greater advances.

This essentially consists of attempts both from a production engineering and biochemical point of view to break away from the traditional method of making bread, which relies still on the cycle time historically and traditionally derived centuries ago from the housewife in her kitchen.

There are entirely new techniques being tried out to enable the bubble formation in bread to be obtained without the lengthy cumbersome procedure of allowing the generation after generation of yeast fermentation bacteria to pass through their life cycle. After all, there are other ways of producing bubbles! A further development, possibly the most important one, is the attempt to break away from the batch process by adopting a continuous process. The basic idea is to produce dough by extruding an unfermented plastic mass almost immediately after mixing the ingredients, rather like a clay extruding plant used in potteries. This would not permit the life cycle of the yeast bacteria to commence and thus one could, by scientific means, maintain a very close control on density, viscosity and thus specific weight of the dough per unit volume. This extruding machine would be followed by a high speed cutter, i.e. a portioning device, and this apportioned lump would be placed into baking tins moving along conveyors. These conveyors can now be conceived as being much longer, thus allowing the individual dough piece to go through its various fermentation cycles and processing equipment as an individual lump of dough having a predetermined quantity of ingredients. In this way a much closer control over weight of the individual lumps can be achieved. Coupled with this a greatly improved climatic control equipment will be required as, of course, the dough pieces can lose weight due to evaporation.

All this promises something which amounts to probably a revolution in the bakery industry, and thus the automatic baking equipment which we shall see in 10 or 20 years' time will undoubtedly differ greatly in its basic conception from the most modern equipment in use today.

"BEDS" — AND THEIR MAKING

by ANTHONY LEBUS,

Joint Assistant Managing Director,

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FURNITURE making is *not* a new art — in fact the furniture of today is not fundamentally different from the beds, the chests of drawers and the writing tables of two hundred years ago. We still use much the same sort of tenons and mortices and dovetails — though they have had to be modified in certain ways to enable us to use woodworking machinery. Many people still have the impression that the use of veneers (which are slices of wood usually less than a millimetre thick) is a new-fangled idea developed in the 20th century, whereas many of the finest pieces of the 18th century were actually veneered in the modern sense of the word.

What then is new in the furniture factory of today? This study deals only with one aspect of the large scale production of popular furniture. A sizeable amount is still made by craftsmen working in small groups who use only a small number of machines. Over 70% of the furniture factories in Britain employ less than 10 men — and there are not more than four who have more than 1,000 workers.

Use of new materials

Many of the materials we use are new. Plywood has only been made in large quantities during the last twenty years. Plastics are a post-war development and are likely to be used in furniture-making in increasing quantities. There have been important developments in glues and surface finishes. Hardboard is an excellent and comparatively new material. It is used extensively by the building industry, and on the Continent is already accepted for use in high quality furniture. However, the British public still has an aversion to it when used in bedroom furniture, but its use is likely to grow. Chipboard is something

newer still and is likely to be used in rapidly increasing quantities.

Side by side with this use of new materials, manufacturers have developed new techniques for handling their products at all stages of production. It is with this aspect of furniture manufacture that this Study primarily deals.

Furniture is a bulky article — and for its size comparatively inexpensive. In its finished state it is easily bruised and damaged. Its raw materials — logs sawn " through and through " or square edged lumber, crates of plywood and bundles of veneer — are heavy and not easily handled by manual labour. Individual parts pass through a large number of operations from planing and sawing through the spindle moulders to such operations as tenoning, morticing, dovetailing and sanding — and there may be a thousand or more different parts in process at any one time, each following its own separate route.

As in all types of manufacture, the essentials are:

a first-class layout of plant;
an efficient system of progression;
a well-developed system of Work Study;
efficient supervision and inspection throughout.

A description of how timber is handled will show the progress that has been made in recent years, and will contrast the difference between the methods used today with those of years past.

In days gone by, barges of lumber were unloaded by a gang of men, each of whom picked up one or two long boards and carried them ashore over a gang-plank and then to the top of a large stack up a series of inclined planks. Here they were piled criss-cross until they were needed for loading into the drying kilns. Alternatively, if the timber had been delivered by lorry, it was off-loaded onto a truck and then measured, board by board, and piled on a stack as already described.

This system of working had a number of obvious faults. Admittedly a large jib crane was used when possible, but even so there was far too much manual handling. It was slow work too — dealing with loads, board by board, in this way. And perhaps most important of all, it involved the use of a number of small gangs, each working in a separate location, which meant that they were out of sight of the foreman in charge.

The idea of handling timber — and veneer and plywood too — in unit loads has changed all this. It is the direct result of the rapid development of the fork lift truck during the last 15 years. It has meant that:

we can centralise under one roof the small amount of manual handling that now takes place — bad weather was an important factor in pre-War days;
work is carried out under the eye of supervision;
field stacks and kiln bogies are loaded and unloaded in unit-loads;
stock-keeping has been made much simpler because the content of each unit is known and remains unaltered from one operation to the next;
fewer men are required — which, apart from making the work less costly, simplifies the task of supervision.

In addition, the development of measuring machines has meant that we no longer need to measure the content of each board by hand with all the clerical work that used to be entailed.

At the outset the choice of the best size of unit load was important. It was essential that a unit load

should not be too large for a field barrow;
should not be too heavy to push by hand;
should not be too heavy for a 2-ton fork lift truck (which is the most convenient size for our field roadways); and
should be a convenient size for loading on a kiln bogey.

After a period of experimentation we standardised on a size 39″ high and 39″ wide. The length is not important and depends on the length of the log — though it must not exceed 16′ if the timber is to go into the kiln.

As far as possible, we arrange for lorries which deliver timber to us, to be loaded in such a way that they can be unloaded either by fork lift or by jib crane. We have tried to do the same with barges but this is not such an easy problem. It is simple to arrange for sling-loads to remain undisturbed once they have been placed on the barge. This speeds the rate of unloading but because it reduces the carrying capacity of the barge by about one-third, it is entirely uneconomic.

A special problem

The unloading of barges of plywood presents a special problem. Individual crates are too heavy and too unwieldy to be moved by hand. The use of a large jib crane is uneconomic. We are, therefore, developing the use of a small portable air-operated gantry crane which can travel along the gunwales of the barge and can be lifted and placed in position by the jib crane. This small gantry crane can be operated by two men only, who pile crates into sling-loads ready for lifting by the large jib. Air operation has purposely been chosen for safety reasons.

Square-edged lumber delivered by barge also presents an interesting problem. Boards are picked up individually from the hold of the barge and deposited on a special type of chain elevator which can be lowered into the hold. At the landward end of this elevator conveyor our plan is to install a measuring machine, a metal detector and lastly a device for sorting boards according to their length, ready for the next operation (Fig. 1).

After unloading, the next operation is the preparation of unit loads for air-drying and kilning.

The sawn logs are deposited on a heavy roller runway some 60 yards long, which provides a bank of work (Fig. 2). Each log may weigh up to three tons and in the past was hauled along the runway by hand. This was an arduous and, therefore, costly business. To solve this problem we have now added a powered drag-chain, into which a hook can be inserted with a safety slipping attachment.

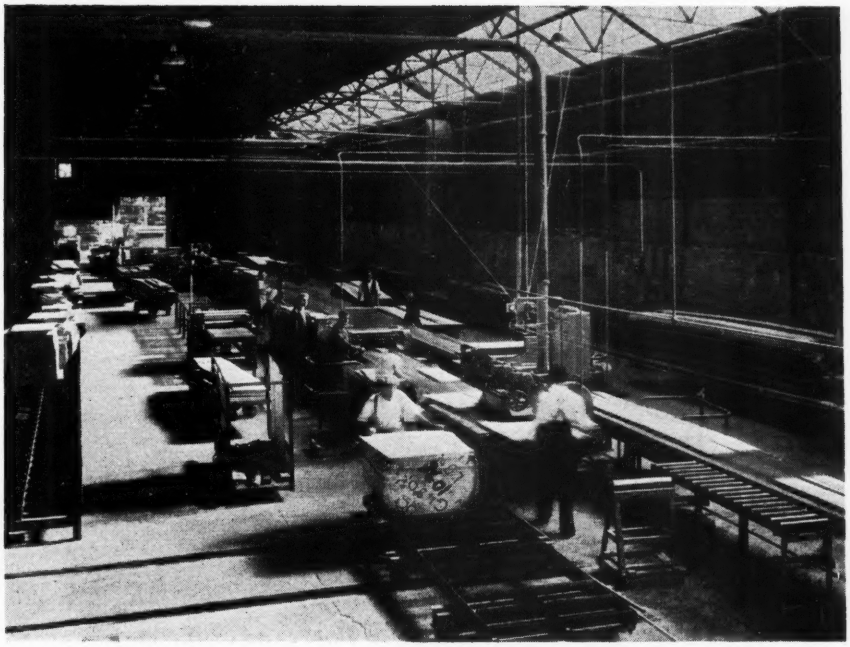


Fig. 1. On the right — ripping, measuring and metal detecting and (in the distance on right) piling ready for kilns.

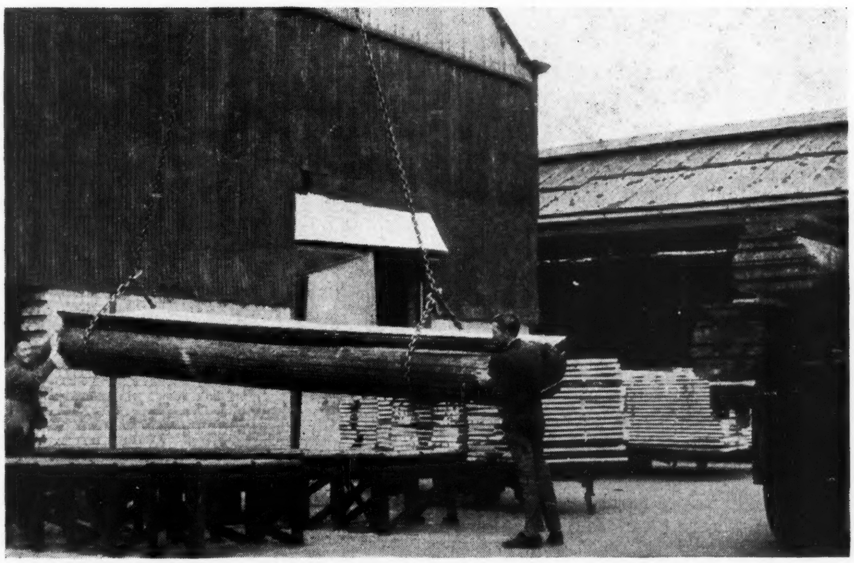


Fig. 2. Unloading sawn logs from lorry and piling on to roller runway.

Fig. 3. Loading a kiln bogey by fork lift truck.

This input runway feeds a succession of operations all of which are linked together by a powered conveyor.

Boards are ripped in their width if they are over 22″ wide. They pass under a detector which brings to light any board containing metal, and they are measured on the move.

The final operation

The final operation of this series is the building of unit loads, interleaving each layer of boards with spacing sticks (which allow the passage of air for drying the timber).

The unit loads are then ready either for storage in the open for preliminary air-drying, or else for building into bogey-loads ready for kilning (Fig . 3).

Importance of handling aids

In all these operations material handling aids play an all-important part. The same applies to the handling of timber in the store of dry-stock after kilning, where again the same principle of unit-loads stacking is applied. These subsequent operations have also been streamlined and substantially modified in the years since the War.

Plywood and veneer do not offer quite the same opportunity for mechanisation, but mechanical aids are being used to assist storage and subsequent issue to production. Labour is restricted to the essential tasks of inspection and grading.

All this appears to be a very long way away from a discussion about "*Beds*". In point of fact, it is fundamental. And there are a number of important lessons to be learnt from the changes that have taken place:

(i) keep a product moving whenever possible;

(ii) move it around as little as possible — and handle it manually as little as possible;

(iii) concentrate the working area so that work is carried out under adequate supervision.

These same rules apply equally well to all the subsequent operations of furniture manufacture and *Beds* are no exception to the rule.

"BOATS"

by C. G. JAMES,

O.B.E.(Mil.), A.F.R.Ae.S.,

Assistant Manager, Fairey Marine Ltd.

THERE is something deeply satisfying in the building and sailing of boats. This satisfaction of a fundamental urge is not surprising, however, for boat building (even if the 'boats' were only a floating log, or a bunch of reeds lashed together) is older than agriculture and much older than the invention of the wheel — and all that 'wheels' imply. This does not mean that boat builders have held on tenaciously to old and conventional techniques, but neither does it mean that the older craftsmanships have been excluded. The design and building of beautiful boats owes almost as much to art as it does to science and the best products have a charm resulting from a combination of the two.

The manufacture of hot moulded boats by Fairey Marine Ltd., therefore, is a successful effort to produce high-class boats by means of a marriage of sound and modern production methods and techniques to the older craftsmanships.

Fairey Marine Ltd. was founded in 1946 as a subsidiary to the Fairey Aviation Company Ltd. at Hamble. The site had obvious advantages, being on Southampton Water and possessing slipways to the Hamble river. The factory buildings were modern, spacious and well lighted, and the project was backed by the research and laboratory facilities of the parent Company and by the experience of its production engineers. In addition, a nucleus of skilled boat building craftsmen was available, though this labour had to be trained in the new techniques, resulting in the production of quality boats in quantity.

So successful has this project been that from an output of approximately 100 boats in 1947, Fairey Marine had, by the end of 1956, produced nearly 4,500 boats — approximately 30% of this production being for export. The production target for 1957 is 1,000 boats — boats ranging in size from 7′ 6″ dinghies to 26′ Atalantas.

The market for boats

The growth of recreational boating and yachting in Great Britain since the War has been phenomenal. No longer is it necessary to be comparatively wealthy to enjoy a sport which has so wide an appeal to young and the not-so-young. And this enthusiastic growth is world-wide, as the following American statistics indicate:

TABLE 1

Growth in Numbers of Recreational Craft *in use* in U.S.A.

Year	*Number of Boats*
1930	1,500,000
1947	2,440,000
1953	5,023,000
1956	5,971,000

The estimated figure of 5,971,000 recreational boats in use on all U.S. waters shows that one boat is in use for every 29 persons — a proportion that is probably higher than any in the world.

The American boating community uses outboard engines to a much greater extent than any other country, and the following are the statistics for outboard engines produced and in use for the years 1952 - 1956:

TABLE 2

Annual Production of Outboard Engines	*Number of outboards in use (current year plus 11 years previous production) less wastage*
1952 — 350,000	2,895,000
1953 — 464,000	3,189,000
1954 — 450,000	3,639,000
1955 — 470,000	4,109,000
1956 — 640,000	4,500,000

The above Table for *outboard engines* in use, compared with the number of *boats* in use (Table 1) does not mean that Americans use outboard motor

boats almost exclusively, though a large number of boats in use are outboard types. A large number of sailing boats also carry outboards as auxiliary power.

In the year 1956, 28,000,000 Americans spent $1,250,000,000 on boating and yachting *in all its aspects*. It is difficult to assess what proportion of this vast sum was actually spent on the purchase of boats and equipment, but only $4,500,000 worth of boats, marine engines and nautical accessories were imported into the U.S.A. in 1956, i.e. approximately .36%. This may seem a minute sum compared with the money spent by Americans on boating generally, but it is a challenge, and in the opinion of the writer there is an untapped and vast market potential for British boats and equipment in the U.S.A. (and the rest of the world). But the market has to be studied to give the customer the boat and equipment he requires, and which is suited to the conditions under which he operates, for there are 60,000 square miles of natural and man-made inland waters in the U.S. including rivers, lakes and reservoirs, and there are 13,000 miles of tidal shoreline. These waters are served by 10,000 marinas, and waterfront launching facilities, for recreational craft alone, all offering service to boat owners. Finally, there are 807 yacht clubs listed in Lloyd's Register of American Yachts, with an additional 820 affiliated yacht clubs. No one will question the fact, therefore, that the sales potential for recreational boats of all types is almost

TABLE 3
List of Types

Type	*L.O.A.*	*Beam*	*Stripped hull weight*	*All-up weight, including centre-board and/or engine*	*Sail area*
R.Y.A. Firefly. Racing dinghy	12′ 0″	4′ 7″	160 lb.	250 lb.	90 sq. ft.
R.Y.A. Swordfish. Racing dinghy	15′ 0″	5′ 3″	300 lb.	400 lb.	130 sq. ft.
14′ International dinghy. Racing dinghy	14′ 0″	5′ 6″ (max.)	225 lb.	325 lb.	150 sq. ft.
Sailing Duckling. Junior class or sailing tender	9′ 0″	4′ 0″	120 lb.	140 lb.	54 sq. ft.
Rowing Duckling. Rowing tender	9′ 0″	4′ 0″	100 lb.	110 lb.	—
Gannet. Racing or family sailing dinghy	14′ 0″	5′ 6″ (max.)	175 lb.	275 lb.	125 sq. ft.
Jollyboat. Racing dinghy	18′ 0″	5′ 2″	260 lb.	360 lb.	160 sq. ft.
Albacore. General purpose dinghy	15′ 0″	5′ 3″	230 lb.	330 lb.	125 sq. ft.
505. Racing dinghy	16′ 6″	6′ 3″	220 lb. (min.)	300 lb. (min.)	150 sq. ft.
16′ 6″ de-luxe motor boat. General purpose motor launch. (Morris Vedette Mk 4.) (Coventry Victor MW2.) (Parsons Ford C4M.)	16′ 6″	6′ 0″	800 lb.	1,200 lb.	—
Flatfish — tunnel stern motor boat. (Coventry Victor MW2.)	16′ 0″	5′ 3″	600 lb.	700 lb.	—
Mudlark (outboard motor). Rowing or outboard day boat	15′ 0″	5′ 3″	250 lb.	280 lb.	—
Gosling ($1\frac{1}{4}$ h.p. J.A.P.). Motor tender	9′ 0″	4′ 0″	110 lb.	165 lb.	—
Finn. Racing dinghy	14′ 9″	5′ 0″	—	305 lb.	107 sq. ft.
Pixie. Double canoe	10′ 0″	2′ 8″	42 lb.	—	—
Pixie. Single canoe	7′ 8″	2′ 8″	32 lb.	—	—
Dinky. Rowing tender	7′ 6″	4′ $1\frac{1}{2}$″	—	76 lb.	—
Atalanta. Bermudian Sloop	26′ 0″	7′ 9″	—	2 tons	240 sq. ft.

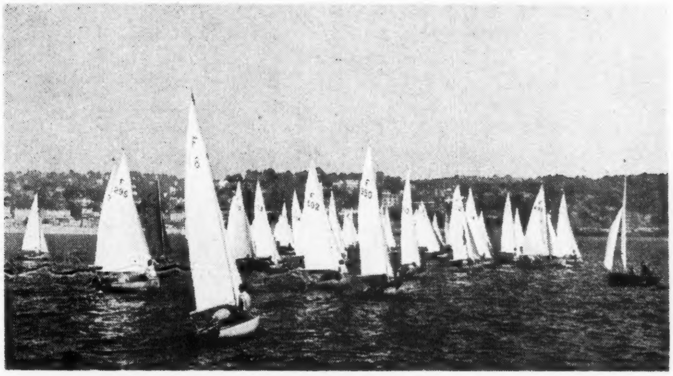


Fig. 1. Fairey 'Fireflies' racing at Torquay.

unlimited, *even if only the American market is considered*, and it constitutes a challenge to quantity — and quality — production.

(NOTE—The statistics given above are extracted from estimates prepared by the Industry Advisory Committee on Statistics of the National Association of Engine and Boat Manufacturers of America.)

Fig. 2. Fairey Marine 18′ 'Jollyboat' — four young people enjoy life.

The boats of Fairey Marine

I make no apology for quoting, in Table 3, a list of the types of boats designed and built by Fairey Marine in the past 10 years, for we are proud of the accomplishment. On the other hand, it may be argued that there are too many types, but the yachting fraternity are certainly not of a pattern and fashions change in boating as in women's clothes. One cannot remain static for to do so is actually to retrogress, and it has only been by constant experiment and by market research amongst the boating communities that we have attained a fair measure of success.

Fig. 3. An 'Atalanta' storming along in the Solent.

Fig. 4. With keels and rudder retracted, 'Atalanta' can be operated in the shallowest waters.

But certain models are strictly one design and cannot be changed in any particular without the consent of the Class Association and the Royal Yachting Association. This is a good thing from the owner's viewpoint, for his own boat cannot be outclassed by someone willing to spend more money on gadgetry or special spars and sails.

Time will not permit individual description of all types, so I have selected three from the range which may be of interest.

The *Firefly* dinghy is strictly one design and probably the most popular and inexpensive modern racing dinghy. Normally raced by a crew of two, it can be used single-handed, and the Single-handed Championship of Great Britain is sailed annually in Fireflies. Being one design, races are won by helmsmanship and the tuning of the boat. Buoyancy tanks are built in, giving a reserve buoyancy of not less than 200 lb. by rule. The hull is a hot moulded triple skin shell — each skin of 2½ mm. thickness. Mast and boom is of light alloy. The boat can be fitted with a reduced rig and shorter mast for junior sailing and the change-over from racing to reduced rig takes only 10 minutes. This is a great advantage to clubs with a large cadet membership.

The 18 ft. *Jollyboat*, too, has become very popular at home and in the United States. It is a one design boat like the Firefly, the Class Association being recognised by the R.Y.A. It has exciting planing performance with its 160 sq. ft. of sail and in addition a spinnaker of 110 sq. ft. can be carried. It is simple and easy to sail and though designed for a crew of three when racing, it is also suitable for family use and can be easily trailed. It is decked fore and aft and has built-in buoyancy. Buoyancy bags may also be added fore and aft to give a total positive buoyancy of 1,200 lb. The hull is hot moulded, with a triple skin, each skin of 2½ mm. veneer. This boat is truly an all-rounder and in 1954 it won the Fastest Boat Race, sailed by Charles Currey, and the Measured Mile, sailed by Peter Scott. In 1955, it was the fastest conventional boat in the radar controlled measured distance, and it also won the 1956 Cross Channel Race, dinghy section, Folkestone/Boulogne, under most exacting conditions with wind forces gusting up to Force 4/5.

I would like to elaborate further on one more boat which is now in production and, though revolutionary, has had a quite phenomenal success — the Fairey *Atalanta*.

This 26 ft. boat can, by using the large central cockpit in addition to the fore and aft cabins, sleep six persons ; it can be trailed and used as a caravan ; it can be sailed in the shallow waters of creeks or estuaries or it can be a deep sea boat or ocean racer in its class. Its twin retractable keels of malleable castings of aerofoil section, each weighing 475 lb., can be raised or lowered by a rotating handle working a worm and bevel mechanism. They can be operated by a woman. A clamping arrangement prevents the keels moving in a seaway. On the other hand, the clamping arrangement is so arranged that the keels will retract if they hit a submerged object. The rudder is also retractable. The mainsail and jib halyard winches can be reached from the cockpit without climbing on deck and the jib tack can be reached, also without going on deck, through a hatch forward. The boat has the usual toilet facilities and

Fig. 5. The 'Atalanta' is easily trailed and can be used as a caravan *en route*.

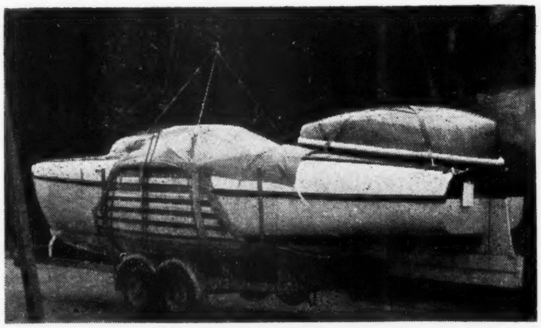


Fig. 6. An 'Atalanta' packed for export on its own trailer. The boat and trailer can be easily slung and carries its own 'Dinky' dinghy on its afterdeck.

also a small galley. The large central cockpit is ideal for a family of six for day sailing and it is well protected and self draining. An auxiliary engine, under the cockpit floor, will give a speed under power of 5 knots. The following are the main dimensions and areas :-

Length overall	26′ 0″
Maximum beam	7′ 9″
Freeboard — forward	3′ 2″
Freeboard — aft	2′ 6″
Headroom under coachroof ...	5′ 3″
Headroom under cockpit tent ...	6′ 3″
Draught — keels raised ...	1′ 6″
Draught — keels lowered ...	5′ 9″
Total weight of keels	950 lb.
Designed displacement ...	2 tons
Area of mainsail	155 sq. ft.
Area of foresail	85 sq. ft.
Area of genoa	115 sq. ft.
Height of sail plan	29 ft. above sheer line

(Spinnaker and Genoa conform to R.O.R.C. requirements.)

The illustrations give a very good idea of the versatility of this interesting boat.

The boats described in the foregoing have been designed and developed by people who have been intimately connected with sailing all their lives — people like Uffa Fox, Alan Vines, Charles Currey, and others who have contributed engineering and production knowledge — and not least the men on the floor who build them and were ready to forget old usages and adopt new methods, however unconventional these may first have seemed.

Materials and methods of manufacture
Materials

Fairey Marine uses wood for its hulls, but we use conventional wood in an unconventional way — unconventional, that is, until the last War brought synthetic resin adhesives and their use for laminated wooden structures into prominence for many structures, including aircraft. We have certainly not discarded the possibility of using other materials such as fibreglass or other laminated plastics for our products, but we feel that our methods, using wood, are the best and cheapest in the present state of knowledge, until more is known of these newer glass and plastic materials, their technique of manipulation and, what is also very important, until their prices are reduced. I might add, however, that we are doing and have done a large amount of research and development on these glass fibres, and fibre and plastic laminates, and it may be that the future may see a boat constructed from a combination of wood, synthetic resin, plastic and light alloy, but that is something definitely for the future.

But at the moment it cannot be gainsaid that wood is a kindly material for boats and possesses advantages, including its strength/weight ratio, compared to other materials. The low specific gravity of wood for a hull is, first, an obvious advantage. For instance, the S.G. of African mahogany is approximately .65, while that of an average glass fibre laminate can be as high as 1.6. Though the modulus of elasticity (E) of a glass fibre laminate can be as high as 3.1×10^6 lb./in.^{2} it can also be as low as 1.0×10^6 lb./in.^{2}. The average E value of African mahogany is about 1.5×10^6 lb./in.^{2} though this figure can be even higher when laminated. It follows, therefore, that unless a fibreglass construction uses an

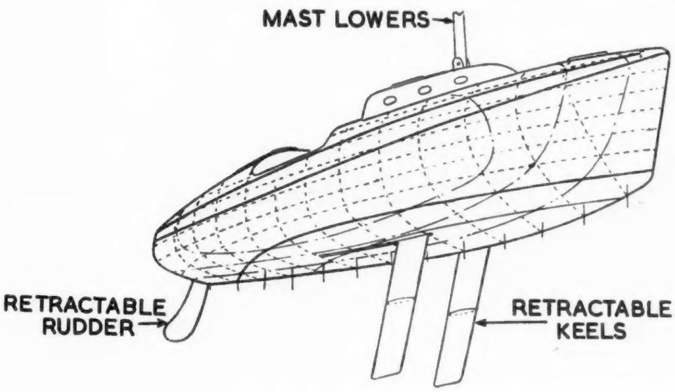


Fig. 7. The 'Atalanta'—perspective of lines and sections.

expensive cellular core sandwiched between the exterior skins, laminated wood has an attractiveness in stiffness, strength/weight ratio and specific gravity. The problems, too, of fatigue and interstitial attrition have not yet been fully solved in laminated fibreglass structures subject to intermittent high stress. Again the fastening or screwing of subsidiary structures to a wooden laminated hull possesses nothing like the problems that such fastenings may have with a laminated plastic hull.

Due to the inherent stiffness and strength of the hot moulded laminated hull, which is practically a monocoque, it has been found possible to dispense almost entirely with conventional frames or timbers and their consequent through fastenings. This lightens the construction considerably and also makes cleaning and maintenance much easier.

It has been said that rot is an ever-present hazard to a wooden hull, but we have found that this is not the case in a hot moulded hull. We have had hulls under test and moored out or submerged for long periods without damage by rot. One hull was half-sunk in the mud in a tidal creek and subject to several years of climatic change, without rot or damage. This hull was not protected in any way by paint or varnish. And so we are reasonably certain that in the case of a hot moulded laminated wooden hull which is impregnated at high pressure by synthetic resin, the risk of rot is reduced to negligible proportions. The resistance to marine borers like teredo is also considerably increased by the high pressure impregnation used in manufacture. Experience has shown that if the borer penetrates at all, it never penetrates beyond the first resin field.

Finally, and in my opinion, it cannot be gainsaid that wood possesses aesthetic qualities, especially when varnished or polished. Most yachtsmen do not subscribe to the view of the person, who, having bought a Sheraton piece, said that after she had spent a long spell on polishing, it would 'come up like new and look like plastic!'.

The plywood used in the construction of our craft is bonded with a phenolic resin glue, complying with the most stringent clauses of British Standard Specification 1203 (synthetic resin adhesives for plywood). The veneers, too, are of high quality, and this combination of timber and glue ensures that the laminate complies with British Standard Specification 1088 — the well-known specification for marine grade plywood.

The adhesives used both in the hot moulding and general construction of "Fairey" craft also comply with the very exacting requirements of the appropriate British Standard Specification for this type of work — namely B.S.S. 1204 (synthetic resin adhesives for constructional work in wood). The adhesive used for hot moulding is Casco-Resin and Hardener combination, developed by Leicester, Lovell & Co. Ltd., of Southampton, with whom we have the closest liaison. This resin/hardener combination provides a long closed assembly period (i.e. the time between assembling and positioning of the spread veneers and applying pressure), and so gives sufficient time for the careful fitting and laying up of the hull and deck planking, especially in the larger craft such as *Atalanta*.

When assembling prefabricated parts, use is made of a resorcinol resin — the most durable type of assembly glue available today. The actual glue used is Cascophen RS-216-M Resorcinol Resin. This product also complies with the most stringent clauses of B.S.S. 1204 and, in fact, is completely durable under all conditions of exposure, including the tropics.

Tests on production panels are carried out at intervals, and similar tests are also made on the bought out plywood used for decking, buoyancy boxes, etc., which must comply with B.S.S. 1088. In addition, completed boats — test boats — are used for exposure tests and these boats are exposed to the weather without proper maintenance in order to simulate the worst possible conditions of use.

Methods

It goes without saying that these moulded boats could not be built to a price and in quantity production unless large scale jigging and tooling was embarked upon, with the consequent large financial outlay involved. The largest single outlay (apart from fixed equipment such as autoclaves and their heat and pressure supply) is, of course, the mould on which the boats are built.

The almost solid male wooden mould is constructed bread-and-butter wise of 4" planking which is glued and pegged together and then carefully fashioned and faired to the interior shape of the boat. From experience, allowance is made for shrinkage. The mould is recessed to take the stem, hog, keel and transom, as these members are integrally moulded into the boat. The planking of the prototype of a new design is then layered up dry, that is without resin, on the mould, each skin being laid up diagonally and approximately 90° to its neighbouring skins. We generally use $2\frac{1}{2}$ mm. thick veneer for the planking, each plank — if such a thin strip can be called a plank — being about 6" wide. Some tailoring to suit curvature is always necessary, but after the planks have been satisfactorily fitted they are numbered and removed and spindling templates or pads made of each 'plank'. The planking of future boats is then roughly cut on the bandsaw in wads and also spindled to shape in convenient 'wads' of six or even more. The numbered wads are then stored in racks adjacent to the mould.

The operator draws the appropriate skin from the rack and staples it to the mould. The first skin carries no glue, the second and subsequent layers carrying the glue film. As the second skin is applied and stapled down to the first, the staples holding the first skin are removed. The planks are glued, one side only, by being pressed through the rollers of a glue spreading machine. The glue mix is rigidly inspected for correct mixture and pot life. The staples and stapling machines are very similar to the ordinary office stapler for papers, except that they are more robust and in some instances can be pneumatically operated to save wear and tear on the operators' hands.

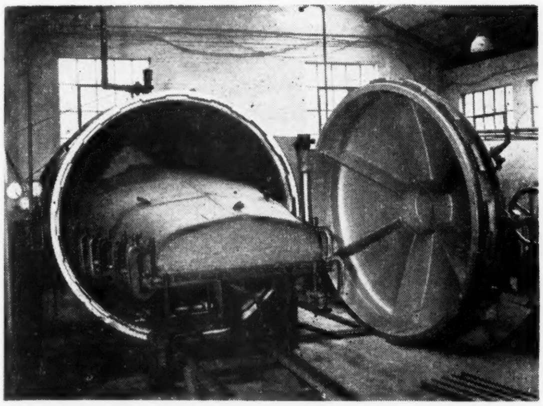


Fig. 8. With rubber bag fitted, a hull on its mould enters the autoclave for hot moulding.

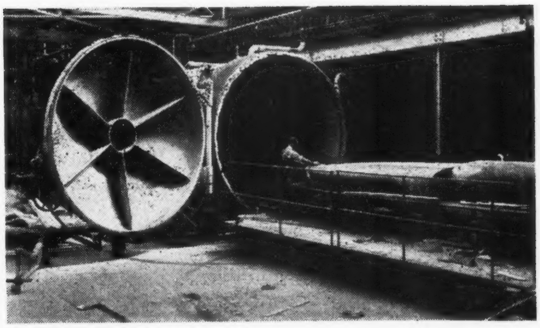


Fig. 9. One of the largest of the Fairey Marine battery of autoclaves. 'Atalanta' top deckings being prepared for moulding.

The mould itself is mounted on a flat metal plate carried on a trolley or bogey moving on a rail track. The plate is larger than the mould, to allow the rubber bag, which is lowered on to the assembly, to be clamped down around its edges to ensure a good vacuum. After ensuring that all the planks are snugly fitted and there are no overlaps, a vacuum of approximately 27″ of mercury is applied and another check made to ensure that planks are fitting correctly with no overlap. In the rare instance of a local overlap occurring, it is comparatively easy to tap the offending plank back into position with a mallet.

The whole unit is then wheeled into the autoclave where steam heat up to 100°C. and an additional pressure of approximately 45 lb. per sq. in. is applied, making a total pressure of approximately 60 lb. per sq. in. on the planks to ensure good contact while the cure takes place. The initial hot cure takes approximately half-an-hour, but this, of course, varies with the type of boat and the number of skins used for the shell. The number of skins used may vary from three in the case of a small dinghy to five or six in the case of a large boat or high speed launch. Constant supervision of curing temperatures is carried out by electric thermocouples under the rubber bag and near the surface of the mould, and samples of the laminate are tested by the laboratory after hot curing to ensure consistency and strength.

After hot curing, the complete shell is removed from the mould and allowed to stand for several days for final curing before being trimmed and worked upon.

As already stated, the stem, hog, keel and transom are integrally moulded into the shell and these members are made up into jigs to ensure interchangeability and dimensional accuracy. In the case of the stem, keel and hog, these are also of laminated construction. Decks, buoyancy tanks, centreboard cases and other components are all jigged, tooled and made up as units to ensure the minimum of trimming on assembly. All plywood used for components complies with B.S.S. 1088 (plywood for marine craft), which means that it is resistant to bacteriological attack and also has to resist, without delamination, 72 hours' immersion in boiling water.

Masts, booms and fittings

Except in the case of *Atalanta* and one or two other boats, most of our masts are of light alloy corrosion resistant drawn tube, the masts being of streamline section. The track is an integral part of the drawn

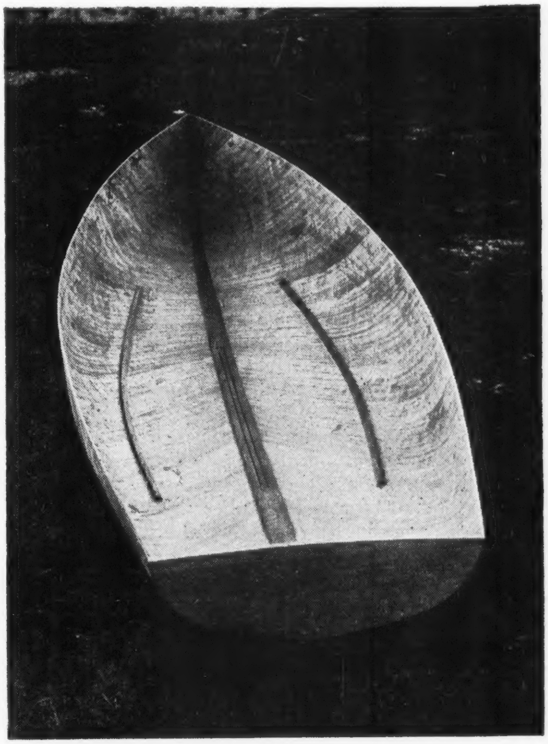


Fig. 10. A Fairey 'Swordfish' shell, after removal from the mould. It will be noted that the transom, hog, stem and bilge rails are moulded *in situ*.

section. We have standardised on two sizes of mast section for the smaller boats.

Although all masts are sealed to make them watertight, the topmast tapered portion is of spruce to aid flotation if a capsize occurs and if the boat is lying on its side. In the larger dinghies the main and jib winches, also of corrosion resistant light alloy, are built into the mast. Crosstrees are also of light alloy.

The masts and booms are drilled for their various fittings in longitudinal channel jigs through hardened bushes. The standing rigging of stainless steel is prestretched before making up and then spliced or Talurited to length in jigs to ensure interchangeability.

Corrosion-resistant light alloy or stainless steel stampings or pressings are also used for a variety of fittings on the boats. Some rudder blades are of light alloy with wood stocks, others have light alloy stocks and wooden blades, while in the case of *Atalanta*, the whole retractable rudder assembly, i.e. stock, cheeks, blade, gudgeons and pintles, is made in BSS.N56 material, argon arc welded, to lessen distortion and also to ensure absence of fluxes which may cause corrosion under marine conditions.

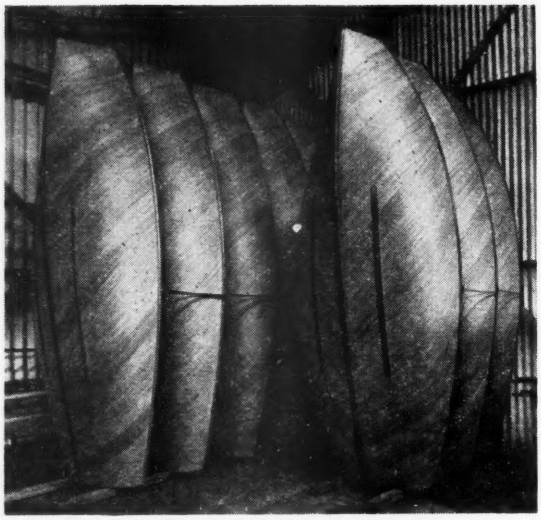


Fig. 11. Fairey 'Firefly' shells after moulding.

Conclusion

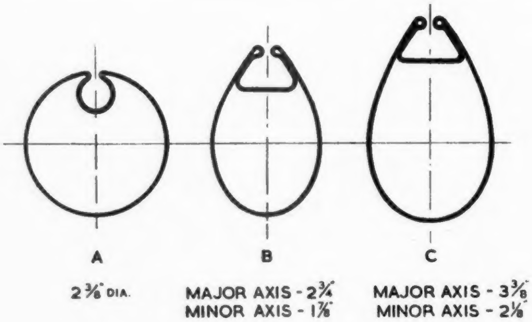
The main theme of this Conference has been automation and there is no doubt that automatic production will bring (as the Chairman of Council has said) social changes of the most beneficial kind, notable of which will be increased leisure for many. How better could this leisure be spent than in the sailing of boats ? Though it may sound trite, we of Fairey Marine believe that we have added something, however small, to the sum total of happiness of this world.

For myself, it is indeed pleasant to be connected with an industry which, because of its emphasis on up-to-date production methods, can provide a sound article and so much pleasure to the users of its products. Recreational boating and yachting is 'snowballing' each year because it is now reasonably cheap, and in addition it would be difficult to find a sport or pastime which has such a healthy outdoor appeal to the young and the not-so-young.

Most of the range of Fairey Marine boats can be purchased as kit sets for home construction, or the hulls supplied in quanitity to smaller yards without our facilities. We can even supply our 26 ft. *Atalanta* in component form for other boat builders or amateurs possessing the necessary ability and facilities to complete.

In conclusion, I would like to thank the Directors of Fairey Marine for the encouragement given in preparing this Paper, though all opinions expressed are solely my own.

Fig. 12. Fairey standard mast and boom sections.



"BEER"

by G. W. BARTON, A.M.I.Mech.E.,

Senior Assistant Engineer,

Arthur Guinness, Son & Co. (Park Royal) Ltd.

BREWING is one of our oldest industries and in the main is still carried out all over the world by traditional methods in rather antiquated premises.

The brewing process has remained unchanged for centuries. It is essentially a batch process and is basically the same for all types of beer; although it is dangerous to prophesy, radical changes permitting a fully automatic and continuous process are not envisaged.

Mechanisation, with simple automatic control devices and instrumentation, has helped to provide greater productivity and progress of this type has taken place in every brewery to a greater or lesser extent.

Circumstances usually dictate that an increase in capacity, or the inclusion of an additional operation in the process, involving extra plant, is met by building on to or otherwise adapting existing buildings, This method, though unavoidable, often produces an arrangement leaving something to be desired.

Even when it is possible to build a new brewery, the limits set by the available site may impose restrictions on the layout. From this point of view, therefore, those responsible for the planning and construction of the Park Royal Brewery were specially favoured (Fig. 1). It was built on a new and extensive site, where the buildings and plant could be arranged in the most suitable positions relative to one another, whilst at the same time leaving plenty of room for expansion. It was also possible to incorporate the many improvements in method suggested by 175 years' experience of brewing Guinness at St. James's Gate Brewery, Dublin.

As in the case of the parent Brewery in Dublin, the Park Royal Brewery produces and sells Guinness in bulk. From Park Royal, some 45 million gallons per annum of Guinness are despatched to brewers and bottlers in containers varying in size from the smallest cask holding 4½ gallons to the largest road tanker holding 3,000 gallons.

Fig. 1. The Park Royal Brewery.

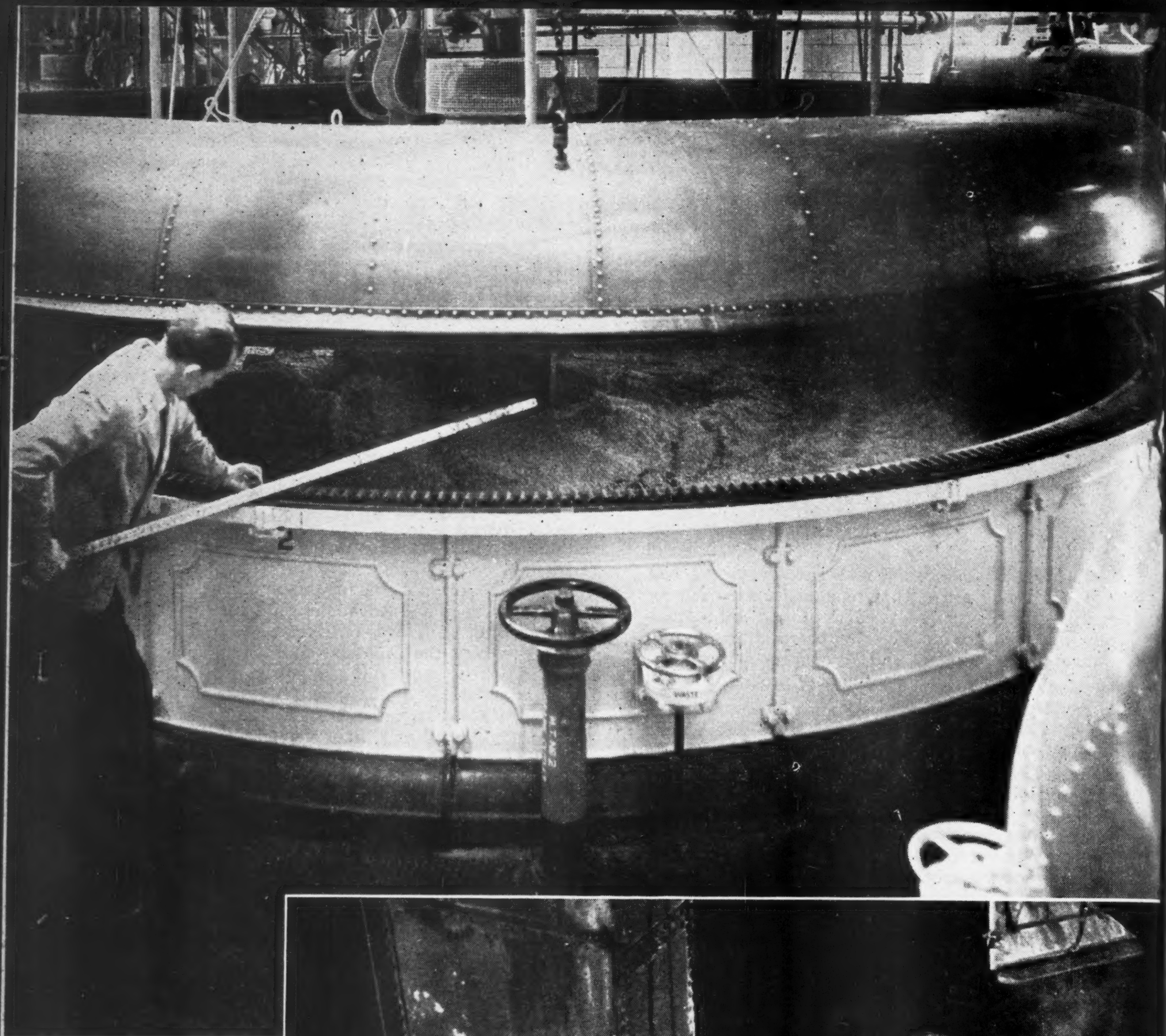


Fig. 2 *(above)*. One of the seven mash tuns, showing contents.

Fig. 3 *(right)*. Removing the spent hops by manual labour. At Park Royal this is now done mechanically.

Although the manufacturer's price of Guinness in this country today is equivalent only to some 13% of the cost of a ½-pint bottle of Guinness to the consumer, efforts to maintain quality and to increase both productivity and efficiency have always been made at Park Royal in order to offset as far as possible the continual rise in the cost of materials, labour, overheads and services.

This policy has enabled the Brewery to hold its selling price steady since 1951 and to increase sales at the same time.

Some of the changes in method and technique which have been made at Park Royal and have resulted in the quality of the product being maintained, savings in labour or materials and increased productivity and efficiency, are outlined below.

Removal of spent grain from mash tuns and spent hops from hop backs

Mash Tuns

That part of the process which takes place in the mash tun is roughly similar to that which takes place in the humble teapot. The Guinness mash tuns are cast iron vessels, each 20 ft. in diameter and about 7 ft. deep (Fig. 2). At the completion of infusion about 20 tons of spent grain must be removed and the vessel cleaned and prepared for the next mash.

It is usual for this material to be shovelled out manually (an arduous and unpleasant task) but Park Royal is one of the very few breweries where the mash tuns are emptied mechanically.

At Park Royal a quantity of liquor is left with the spent grain and the mixture is pumped away.

Although the pumping system was installed primarily to remove an unpleasant task from the duties of the Brewhouse Labour Force, it has also effected a considerable money saving.

Based on a brew involving six mash tuns (there are about 350 such brews per annum) the comparative labour figures are:-

	Man hrs./brew
Manual emptying and cleaning	66
Mechanical emptying and manual cleaning	12

Hop Backs

The liquor (known as wort) from the mash tuns is boiled with hops in large copper vessels. After boiling, the contents of these vessels is run off into hop backs having false bottom plates which keep back the hops, but pass the hopped wort.

The hop backs are of copper bearing steel, about 26 ft. 6 in. diameter and 9 ft. deep.

Again the traditional practice is to remove the spent hops manually (Fig. 3), but at Park Royal this, too, is done mechanically in a similar manner to that for spent grains, originally for the same reason and with the same result.

Comparative labour figures based on a six mash tun brew are:-

	Man hrs./brew
Manual emptying and cleaning	41
Mechanical emptying and manual cleaning	8

Cask and vessel cleansing

Guinness is a naturally conditioned product and is not pasteurised ; scrupulous care is therefore taken to ensure that all vessels and containers with which it comes into contact are thoroughly clean.

As stainless steel and aluminium can be kept much cleaner than wood, these materials are replacing wood at Park Royal both for brewing vessels and for containers for the finished product.

Cask Cleansing

Casks range in capacity from 4½ gallons to 104 gallons and all these are cleansed by washing and steaming (Figs. 4 and 5).

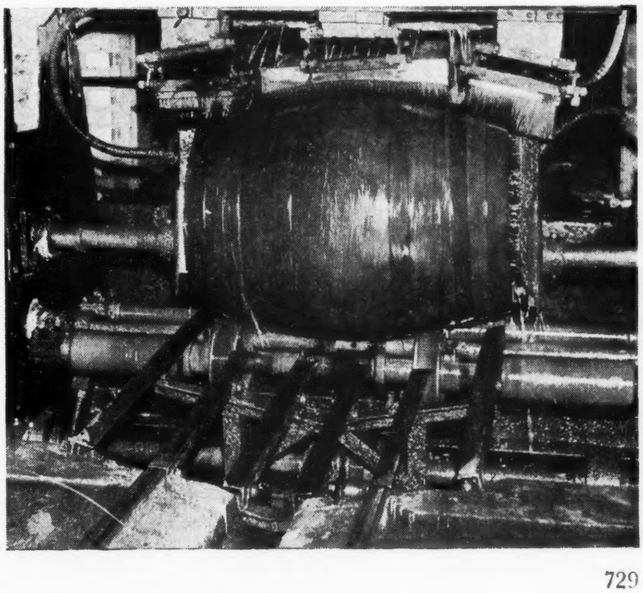


Fig. 4. A cask being washed externally.

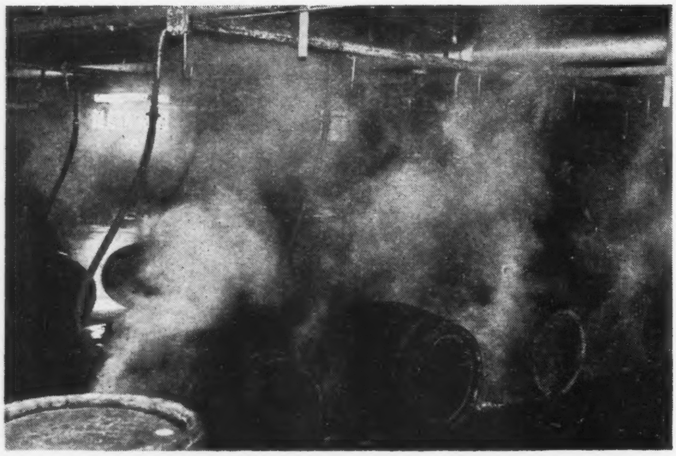


Fig. 5. Casks being steam sterilised.

Originally each cask was washed externally by one machine, internally by another, and was afterwards steam sterilised. With this system the internal washing water was injected in one 'burst', as was the steam for sterilising.

This arrangement has been displaced by one in which the three operations are performed on one machine (Fig. 6). This saves manhandling between operations without any increase in power consumption. Casks washed and sterilised on the machines now in use are also much cleaner, as a result of the washing water being injected by four consecutive nozzles and the steam by five consecutive nozzles.

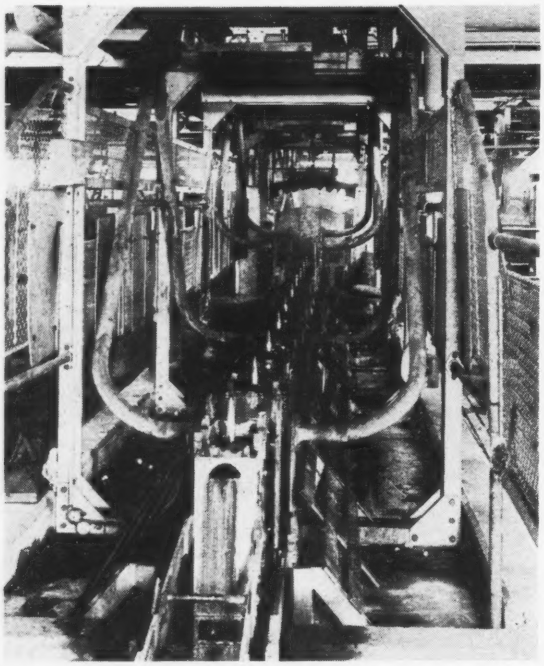


Fig. 6. The present method, whereby casks are washed internally and externally and also sterilised in one machine.

One of these machines has roughly the same capacity as four lines of those they replace.

Comparative figures for the two systems are as follows :-

Original Method

Output	60 casks per hr. per line
Internal washing water consumption	4.8 gall. per cask
Steam consumption ...	3.3 lb. per cask

Present Method

Average output ...	200 casks per hr.
Average washing water consumption	7 gall. per cask
Average steam consumption	2½ lb. per cask

Saving in labour per cask 33%.

Vessel Cleansing

The smaller vessels are water flushed and steam sterilised, but such vessels as vats are too large for this treatment.

The vats are about 20 ft. diameter and 22 ft. deep. Originally they were all made of oak, but stainless steel is displacing wood as the vats fall due for renewal.

Before each filling the wooden vats are scrubbed thoroughly by a team of three men. Two men wield long-handled brushes from side to side over the internal surfaces of the vessel, whilst the third man manipulates a hose. The work is heavy and demands both dexterity and strength (Fig. 7).

So far about half the vats are of stainless steel and these lend themselves to mechanical washing by medium pressure water and a revolving washer having three nozzles which operate catherine wheel fashion. The machine is merely lowered into the vat and the water turned on for a specified time (Fig. 8).

This system is also in use in other parts of the brewery and its use is being extended.

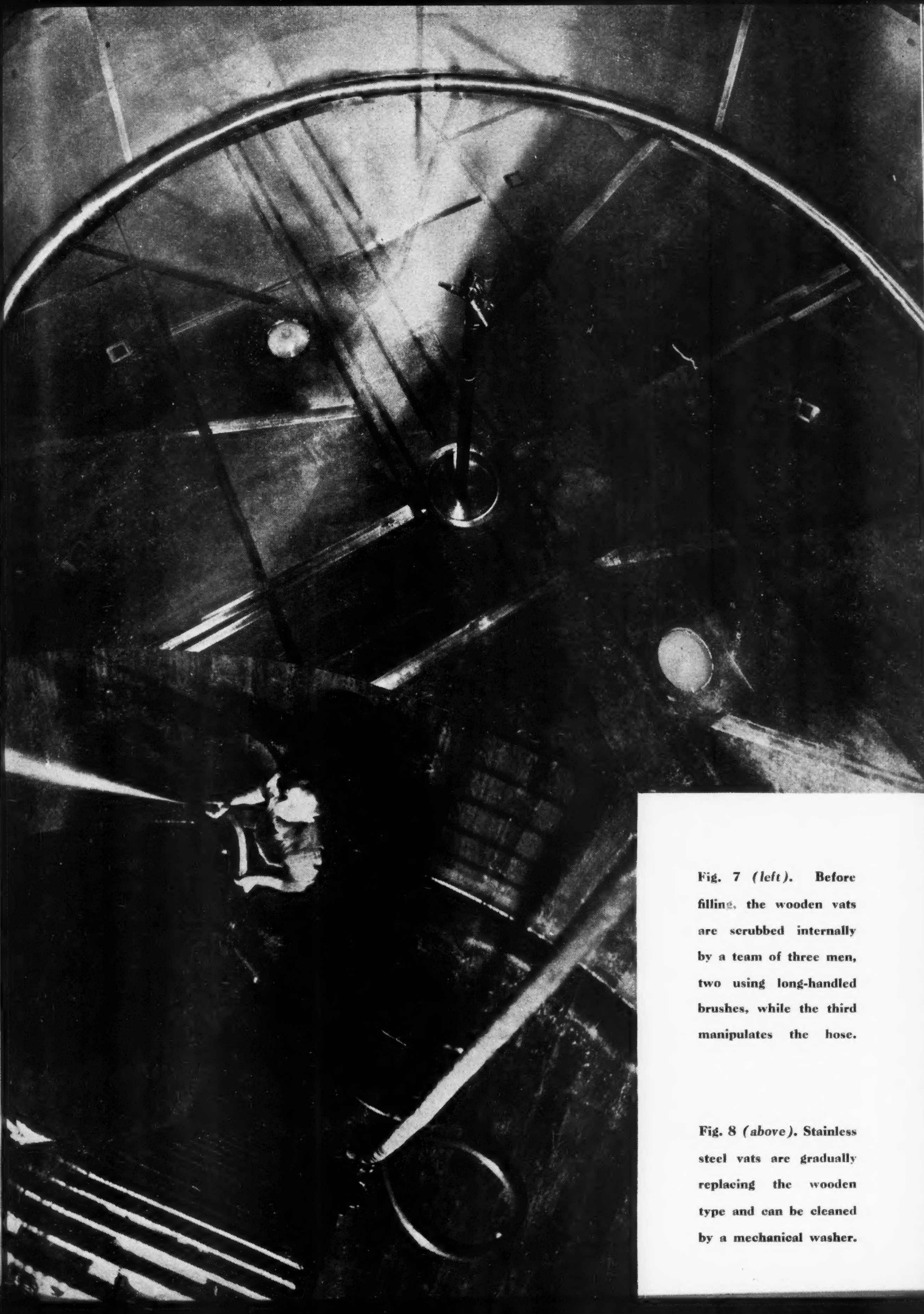


Fig. 7 ***(left).*** **Before filling, the wooden vats are scrubbed internally by a team of three men, two using long-handled brushes, while the third manipulates the hose.**

Fig. 8 ***(above).*** **Stainless steel vats are gradually replacing the wooden type and can be cleaned by a mechanical washer.**

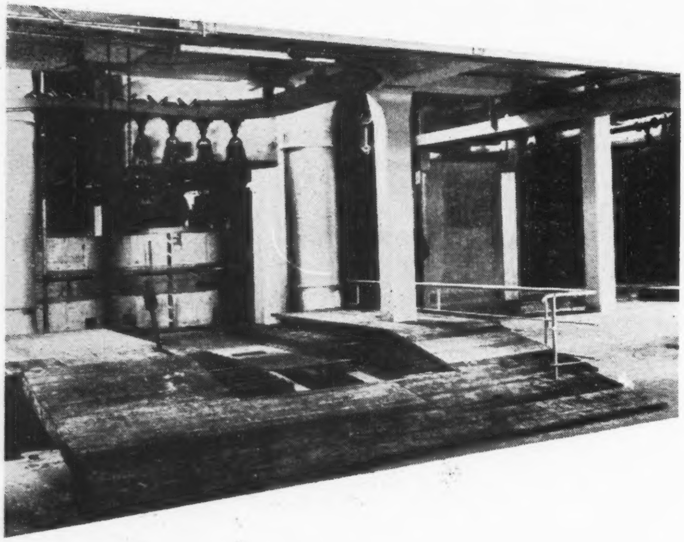


Fig. 9. Part of the monorail and roller conveyor system, used when sterilising and filling transportable tanks.

Each vat is filled about 60 times *per annum* and comparative figures for the two methods of washing vats are as follows :-

Oak vats	9 man hours per vat
Water used ...	about 1,000 gallons per vat
Stainless steel vats	1 man hour per vat
Water used ...	about 1,500 gallons per vat

Delivery in bulk

The growth of the demand for Guinness and changes at many of the bottling stores make it possible to despatch an increasing proportion of the output in much larger containers than the largest cask.

At Park Royal these containers are either road tankers or road/rail tankers ranging from 1,440 to 3,000 gallons total capacity, with compartments holding from 360 to 2,880 gallons.

As the Park Royal Brewery cannot satisfy the demand for Guinness from the whole of Great Britain, some continues to be shipped to this country from Dublin.

Originally this was shipped in cask, but it is now transported mainly in specially designed 500 gallon nesting tanks of stainless steel or aluminium.

The steamers have specially refrigerated holds and were designed for this change. The handling arrangements for the tanks in Dublin, Manchester and Liverpool reception depots have been modernised to obtain the maximum benefit from the new system. Fork lift trucks deal with the tanks on land including loading and unloading lorries.

The tanks are washed, sterilised and, of course, filled in Dublin where a new monorail and roller conveyor system was installed for the purpose (Fig. 9).

The savings in cost effected by bulk delivery are from 10% to 15%, amounting to some £100,000 *per annum*, but what is perhaps more important is the greater cleanliness of this mode of delivery and the resulting improvement in the condition of the product.

Instrumentation

Work on the construction of the Brewery started in 1933, when gauges and instruments were still regarded as luxuries in many quarters. At the outset, therefore, instruments on the engineering plant were few in number.

War conditions produced a general drive for increased fuel efficiency and meters to indicate and record the consumption of steam, electricity, water, coal and gas were installed in the main departments. The cost of these was more than saved on the fuel bill in the first year.

This drive has been sustained by fuel crises and the continual rise in the cost of fuel in all its forms.

Additional gauges and meters have been installed, heat recovery and retention measures extended and changes in the timing of some brewing operations introduced to reduce peak demands. Each item has contributed towards a general increase in efficiency with a corresponding saving in money and fuel consumption.

The yardstick of overall efficiency in a brewery is heat used per barrel (36 gallons) brewed. At Park Royal this figure has fallen from about 500,000 B.T.U. to 320,000 B.T.U., despite increases in electricity demand from additional plant.

Some of the more interesting examples of instrumentation are :-

1. *Automatic boiler control.* This is an electric pneumatic hydraulic arrangement regulating the forced and induced draught fans and the grate speed according to the boiler steam pressure.
2. ***Automatically controlled, steam heated, absorption refrigerating machine* of 1,000,000 B.T.U./**

hour capacity chilling water for general cooling purposes.

3. *Automatically controlled rackings chiller.* This adjusts the output from a positive displacement pump, according to the temperature of Guinness leaving the cooler. The system is pneumatic, mechanical and includes an hydraulic variable speed gear box.
4. *Automatically controlled yeast chiller.* This regulates the flow of brine to provide a constant yeast temperature, using a pneumatic controller.
5. *Brightness metering system.* A continuous sample of the Guinness flowing to the racking points passes across the beam of a photo/electric cell via a small glass tube. The photo/electric cell is connected to a brightness indicator and recorder ; the former carries an electric contact which rings an alarm bell should the brightness fall below a minimum value, so that appropriate action may be taken.

Whilst it is difficult to measure direct savings resulting from these examples, it may fairly be claimed that additional labour would be needed but for the instrumentation.

Current developments

Two projects on which work is proceeding are outlined below as interesting examples of further mechanisation of an already highly mechanised plant :-

(a) *Racking by Pre-set Meter.* The traditional method of filling casks is volumetric and manual. The system includes a header tank or racker having a float valve to control the content and a number of racking hoses, each controlled by a cock.

Casks reach and leave the racker by rolling. They are filled by gravity under a slight head, the whole operation being rather slow and the filling time varying with the size of cask.

Trade requirements for Guinness in some of the smaller metal casks necessitated an increase of about 84% in the rate of racking. It was found that this would necessitate nearly 100% increase in the labour force on the racker concerned, so the possibility of racking by meter was reviewed.

Meters have been in use in the U.S.A. for excised liquors for many years, but meters of sufficient accuracy and cleanliness to satisfy brewers and the Weights and Measures Inspectorate in this country had not been developed over here.

A meter manufacturer, well known in the petroleum industry, was found willing to produce a pre-set flowmeter, having the necessary standards of cleanliness and accuracy ; a development programme was, therefore, undertaken.

The requirements were met in full and conversion of the first racker to include pressure fed, pre-set, totalising, piston type meters is in hand (Fig. 10).

Although the new system will be manually triggered, the filling cycle will be automatic once the meter has been started. It will be simpler and cleaner than the old method and will include a conveyor feeding and discharge system.

Tests with the prototype unit show that the required rate of racking can be achieved with ease by the existing labour force. An idea of the time saved by the pre-set meter will be gained from the following comparison :-

Old method ... 8 gallons racked in 65 secs.
New method ... 8 gallons racked in 33 secs.

It is expected that the cost of the new system will be recovered in two years.

(b) *Bulk Handling of Grain.* Some 60,000 tons of malt and barley are delivered annually to Park Royal by road and rail.

Once emptied from its sacks, the material passes through many weighing, cleaning, screening, grading, storing and transfer operations mechanically, on hundreds of yards of conveyors and elevators.

Traditionally each sack is removed from the road or rail wagon by hand and emptied into the receiving hoppers, the maltsters' packing

(*concluded on page* 704)

Fig. 10. Prototype pre-set flowmeter on experimental rig.

EDUCATION for MANAGEMENT—ARE WE FALLING BEHIND?

by G. W. PITT,

A.M.I.Prod.E., M.B.A.(Chicago). Dip.Econ., Pol.Sc.(Oxon.).

Mr. Pitt served his engineering apprenticeship at S. Smith & Sons (England) Ltd., at Cricklewood and Cheltenham, and subsequently became a work study engineer, process planner and estimator at the Cheltenham factory for five years. He then spent three-and-a-half years at the Lockheed Hydraulic Brake Co. Ltd., Leamington Spa, as Technical Assistant to the Chief Inspector, and subsequently as an inspection foreman.

Mr. Pitt obtained the City and Guilds of London Institute Certificate in Machine Shop Engineering, and the Higher National Certificate in Production Engineering, as well as preparing for the Diploma in Management Studies, through evening classes at various technical colleges.

In 1954, he went to Ruskin College, Oxford, to study economics and political science. During his two years at Oxford, he won a scholarship to the School of Business of the University of Chicago, where he graduated with the degree of Master of Business Administration in August, 1956. His experiences there form the basis of this article.

Mr. Pitt is now a Lecturer in the Department of Management Studies, at the Polytechnic, Regent Street, London.

THE main purpose of this article is to appraise business administration education in America as experienced by a British student. It is not an attempt to describe American business education as such, for two reasons. Firstly, many sources of information already exist for this purpose and, secondly, it is dangerous to generalise about anything American; business education is no exception. An attempt will be made to answer such questions as "Does the course meet the needs of American business?"; "Who are the people most likely to benefit?"; "How would such a course meet present needs of business and management education in Britain?" and, if it does not, "What modifications are needed to make it acceptable in the British educational and industrial setting?".

We will first examine the type of course offered at the School of Business of the University of Chicago. The School was founded in 1898 and is the second oldest in America. It can be regarded as one of the leading schools of its type in the country. As there is a great variety in the type and emphasis of business administration and management courses provided in the 166 universities or colleges offering these subjects, it is not easy to suggest that the Chicago course is typical, but it has many features common to these courses. It has certain advantages in that the School is part of a University well connected with industry (the University was founded by John D. Rockefeller). Its relatively long history brings the advantages of long experience in teaching methods and research; the danger of a conservative or traditional trend over the years has been successfully avoided. The unique environment of a city like Chicago, with its wide diversity of manufacturing, finance and trade, provides for the Faculty and students valuable means of close contact and exchange of ideas with practising business men.

Details of courses

The bulletin of the School of Business states the case for business education as follows :-

"The need today for professional education for business administration is clearly defined and growing constantly. Modern business operations and management demand an increasingly high order of technical knowledge and administrative skill. It is now widely recognised that in business, as in law or engineering or medicine, formal professional education is of vital importance in preparation for a career.

"Education for business at the university level offers significant advantages. It conserves time by shortening the period of apprenticeship for higher business responsibilities. It provides a breadth of view and a perspective respecting business activities and problems which is difficult to acquire through practical experience alone. More important, it supplements experience and greatly enhances its work by supplying the valuable insights of theory and of basic principles of business administration."

The School offers four programmes of study :-

1. The M.B.A. (Master of Business Administration) Programme.
2. The Ph.D. Programme.
3. The Executive Programme.
4. The Hospital Administration Programme.

There are three distinct programmes leading to the M.B.A. degree :-

1. Full-time day programme conducted on the University campus.
2. Part-time evening programme, conducted downtown.
3. The Executive Programme.

For the purposes of this article, we will be concerned mainly with the M.B.A. Programme on campus as fulfilled by the writer. The Executive Programme will also be described in view of its many features of interest to British industrialists.

The M.B.A. Programme

The primary objective of the programme is "to provide broad professional education for persons looking forward to positions of executive responsibility in business. The programme is designed to furnish *education* in principles of business management, rather than *training* in specific business operations and narrowly vocational techniques. All major aspects of business management are treated and interrelationships among them are stressed. Students are thus encouraged to view business operations and situations comprehensively. An allied objective of the programme is to provide some degree of specialised education in a selected field of concentration."

Normally, only holders of four-year Bachelor's or equivalent degrees are eligible for admission (usually aged 22 or more at this stage under the American educational system): but the admission requirements of the School are sufficiently flexible to enable others to enter if they can provide satisfactory evidence of self-education or other qualifying experiences, such as business experience, if they pass a general education test. The writer benefited from this flexibility as he was admitted to the School, offered a tuition scholarship, and granted exemptions from five subjects on the basis of his industrial experience, his qualifications through attendance at evening classes over many years and a year's full-time study of economics and political science.

The course consists of 18 subjects; normally three subjects are taken in each quarter (three months). This means that the course can be completed over two years, or 18 months if the student chooses to study in the summer quarter by missing the long summer vacation.

The subjects are detailed as follows :-

A. Basic subject matter — comprising accounting, business economics, statistics and business law.

B. Methods and problems of management — comprising production management, financial management, personnel management and marketing management.

C. Management theory and business policies — comprising business organisation and policies, business cycles and forecasting, and social control of business.

D. Field of concentration — which may be chosen from the following: accounting, business economics, business finance, personnel management, marketing, production, statistics and institution management.

In the "Production" field of concentration the student, having already taken the basic production management course (Production I) required of all degree students, takes three courses covering "the entire field of administration of manufacturing enterprises", and three electives. The former are :-

Production II — problems in integration of technological factors to achieve efficient operations. Case material from companies in several different industries includes problems of analysing and organising processes, planning layouts, scheduling and controlling production, and structuring working relationships in the organisation.

Production III — problems of business policy in the production area. The first half is concerned with problems of executing production policies in terms of the physical process of production, the co-ordination of production with sales requirements, and the integration of production planning and control. The second half consists of problems of formulating policy. Case material deals with actual business situations.

Business Policies — attempts (1) to ascertain what is essentially involved in managing a business firm; (2) to develop a technique for identifying policy issues; and (3) to determine the related co-ordinated plan for executive action.

The three electives are selected from the following :-

One elective from :

Seminar on management functions of the controller.

Problems of financial management.

One elective from :

Personnel management and collective bargaining.

Wage and salary administration.

Industry and the individual.

One elective from :

Market research.

Marketing management : advanced.

A similar system of selection of subjects exists for the other fields of concentration.

The M.B.A. Executive Programme

The stated objectives of the programme are :-

1. To develop facility in the managerial uses of economics, accounting and statistics.
2. To develop a general management approach to business problems — an approach that goes beyond specific departments or functions to a company-wide, or even industry-wide, point of view.
3. To foster a greater awareness of the administrator's responsibilities in an organisation.
4. To develop a sense of the responsibilities of business leaders in our social, economic, and political system.

The programme was established in 1943 for persons already carrying executive responsibility to meet the vastly expanding need for development of executive talent. " The broad aim is the development of solid habits of learning, the ability to reason and the fundamental ethics of rational and integrated judgment . . . It is a concentrated graduate course adapted to the mature interests and needs of the experienced business executive . . . It is an opportunity for men and women in business to share experiences, broaden understanding and develop managerial depth and balanced perspective." It is the only American business course expressly designed for executives that provides a university degree on completion.

Details of the course

About 75 are accepted out of over 250 annual applications for the two-year course. The two years are split into six terms of 11 weeks. Two subjects are taken each term, one evening of three hours per subject per week. In addition to the formal six hours per week, the programme requires extensive reading and preparation of papers which may require a further 20 hours per week.

The 12 subjects taken are :-

Managerial Accounting (two parts) ;
Administrative Relationships ;
Business Economics ;
Industry and the Individual ;
Statistics for Management ;
Industrial Relations ;
Money and the Financial Markets ;
Financial Management ;
Marketing Management ;
Public Regulation of Business ;
Business Organisation and Policy.

Selection

The Executive Programme has been especially designed for college graduates with substantial business experience at an executive level. There is no prerequisite of formal business training, and four years' college education is not essential if an equivalent education has been obtained informally. Application is usually made by Chicago companies who nominate and sponsor selected executive staff, but individual applications receive equal consideration by the School. About 75% of selected candidates are those sponsored by their firms.

The average age of the 75 finally selected candidates is 38 years, with approximately 80% being in the age-range 34 - 45, and most of the remaining 20% below 34 years of age. The average salary being earned is $15,000 per annum. The candidates are usually from the third level of management in the larger companies and the first or second of the smaller companies. Only about five of the 75 selected fail to complete the two-year course through pressure of work, domestic reasons or illness : this gives evidence of great care in the initial selection by companies and in the final selection by the School. It also illustrates the determination and initiative of the candidates, who have to make great personal sacrifice to gain the qualifications.

The composition of the members of the 1955 - 57 Executive Programme group is broken down as follows :-

General administration	25
Engineers and chemists	13
Sales	6
Financial (Treasurer, etc.) ...	6
Accountants	2
Secretaries and assistants ...	5
Personnel	3
Purchasing	4
Officers in the Services	3
Others	3

Impressions of M.B.A. courses

Their relation to British needs

The answer to the question of whether the course meets the need of American business is fairly easily answered. All the evidence is that it does. The traditionally long and close association between industry and the universities ensures this. There is an insatiable demand for young and ambitious persons by business and government, usually as trainees in the first instance, to fill the many junior executive positions available in the expanding economy. The general acceptance of the importance of business education in America is well known. The argument has never much revolved on the principle of education for management, but on the best means of obtaining it and what is the best student material to benefit from it. Most Schools of Business are invaded

in the early Spring by personnel officers from industry who are looking for suitable graduates nearing completion of their course. The larger companies compete with each other in what they have to offer the best graduates, and spend much time and money on impressing upon them the opportunities available. As most of the graduates have come to the School of Business from college their practical business or industrial background is limited, and the larger companies expect to give them a general tour of the business for several months and then further training in their specialised field before they are finally established.

The curriculum has been evolved over many years of experience and it is difficult to see how it can be bettered to meet the stated objectives of the course. The main interest to us is whether it could be transposed to a British environment in its present form. The writer's conclusion is that it cannot, owing to the fundamental differences in the educational structure of the two countries. We have to consider the type of student expected to take such a course in Britain, and his background. Would he differ greatly from the American graduate business student? This depends upon the type of British student being considered. If we take as our first basis for comparison the British student who takes the British Institute of Management/Ministry of Education Diploma in Management Studies, we find that most have usually left school at a fairly early age; have had a good grounding of practical experience, possibly as apprentices, and may have taken a Higher National Certificate. They may, therefore, have been in industry for five to 10 years with a good all-round experience in different departments and different companies. This is the main difference. Therefore, there would have to be some adjustments in the curriculum to allow for the average British student's superior working knowledge of industry. If we consider the graduate trainee from the university who is becoming more common in British industry, we will probably find him, on completion of his training, to be the closest equivalent to the American business graduate. If he could follow up his training by a business course like the M.B.A., he would be well equipped in every way to get the most from the course because of his maturity and prevailing close touch with industry.

Much of this discussion must be hypothetical, because it is difficult to see how a two-year full-time course of this nature, at university level, could be imposed upon the British educational system without a radical change in the thinking of our educationists and universities. This suggests that a course like the M.B.A. Executive Programme described above would lend itself more easily than the graduate programme to immediate application to British industry. It has been adapted from the graduate course to allow for similar factors to those in Britain, although aimed at a much higher level of management than that represented by the average BIM/M.of E. Diploma student.

Method of instruction

This is by lectures, normally for three hours per week, in each subject, making nine hours per week. Extensive reading lists are supplied for each subject; these form the basis for the student's broadening of knowledge beyond the lectures to provide for preparation of papers during the term and for mid-term and end of term examinations. These examinations and term paper requirements vary greatly according to the particular subject. The most important examination in the course is the "comprehensive" in the field of concentration: this is a straight four-and-a-half hour examination, covering the whole field which has been the subject of seven courses, including the three electives. No Master's thesis is required. The Faculty is of high calibre, combining good academic qualifications in their specialised fields with much actual business experience. The members of the Faculty are expected to keep up-to-date with the business world by consultative work and collaboration on business research projects. In fact, there is a danger that the emphasis placed upon research and the interest shown in it by the Faculty may reach the stage where insufficient attention is paid to the mediocre student. Graduates are encouraged to broaden their academic knowledge by visits to local enterprises: to assist this development, groups of students in their respective fields of concentration are formed to enable them to develop their own programme of visits and meetings through the agency of the School's Business Club. There is evidence that the average student is not sufficiently aware of the benefits of such facilities and does not use them enough accordingly. This may be due to the need of some of them to do part-time work while graduates, to maintain themselves, and to the fact that many of them feel that they have benefited already by a variety of vacation work in different enterprises while at college or high school.

Library facilities

The library facilities are excellent. The very extensive American business literature is easily available to the graduates through a well-arranged system, which gives them an equal chance to share a wide range of the available books quoted in the course reading lists. In addition to this literature, there is an extensive periodical library equally impressive in its scope. Much of the literature deals with basic projects of research applied to American business problems. We in Britain cannot remain content with our own relatively limited harnessing of academic resources toward the rapid advance of industry through management education.

Case studies

These are recognised as a valuable means of education in many business subjects, particularly those concerned with organisation, human relations and policy formulation. The Harvard Graduate School of Business Administration has been the leading source of case material for many years: the material has been built up from actual cases in

industry, often through the co-operation of Harvard alumni, who take a great interest in the progress of their "Alma Mater". Experience indicates that cases are the only practicable means of education in many management subjects, where sensibly combined with a few initial lectures. Much depends upon the qualities of the leader of the discussion if full benefit is to be gained. The case system develops students' critical faculties, places upon them the burden of independent thinking and illustrates in practice the advantages of clear and logical analysis of the facts of a situation toward the formulation of a policy. It is not the intention to find what may be the best answer to the problems in a case.

Conclusions

1. The writer is convinced by his experience that American business education has many virtues which British industry, with the notable exception of the more progressively led concerns, is far too slow to recognise.
2. The remarkable vitality and versatility of American business owes much to the educational framework provided for its leaders by the universities, and particularly the better Schools of Business.
3. The continuing dependence of American business upon the ability of the universities to meet its technological, scientific and management manpower needs, is illustrated by the vast sums of money it pours into the universities and the attention it pays to attracting the products of them. Close co-operation and mutual help between universities and business is an essential basis for successful business education.
4. The writer is convinced that any manager who does not recognise Britain's great need for an extension of facilities of education for management is a liability to himself, to his firm, and to his country.

CORRECTION

Mr. R. E. Andrews, Member, of Melbourne, Australia, has kindly pointed out some errors in the Table relating to Fig. 11 on page 176 of the March, 1957, issue of the Journal. Corrected figures appear below:

Pt. No.	*x*	*y*
8	6.012	4.369
9	5.511	5.126
10	4.791	5.678
12	0.743	

RESEARCH PUBLICATIONS

The Institution is advised by PERA that Dr. G. Schlesinger's book on "Accuracy in Machine Tools: How to Measure and Maintain It" is now out of print and cannot, therefore, be supplied. The following I.Prod.E. publications are, however, still obtainable from PERA at "Staveley Lodge", Melton Mowbray, Leicestershire.

"Practical Drilling Tests" by D. F. Galloway and I. S. Morton. Price 21s.

"Machine Tool Research and Development" by D. F. Galloway. Price 10s. 6d.

JOURNAL BINDERS

Strongly-made binders for the Institution Journal, each holding 12 issues, may be obtained from Head Office, 10 Chesterfield Street, London, W.1, price 10/6 each, including postage.

Mr. J. R. Kelly, Member, is now General Manager of the Elswick and Scotswood Works of Vickers-Armstrongs (Engineers) Ltd.

Mr. T. W. Price, Member, has recently taken up an appointment with The British Tabulating Machine Company Ltd., at Castlereagh, Belfast.

Mr. J. W. Taylor, Member, has now taken up the position of Chief Mechanical Engineer with Light Engineering Designs Ltd., Gosport, an associate Company of Westminster Airways Servicing Ltd., also of Gosport. Mr. Taylor is Honorary Secretary of the Southampton Section.

Mr. D. B. Archer, Associate Member, has been transferred to Southern Rhodesia from South Africa, by his Company, H. H. Fraser & Associates (Pty.) Ltd., and is engaged on a general mining application at the Kamativi Tin Mines Ltd.

Mr. K. A. Blumenthal, Associate Member, is now Production Manager with the Compton Engineering Co. Ltd., London.

Mr. C. I. R. Bradley, Associate Member, has recently been appointed Lecturer in Production Engineering in the Mechanical Engineering Department of the Woolwich Polytechnic, London.

Mr. E. R. Cash, Associate Member, has been appointed General Works Manager to The A.P.V. Company Limited, Crawley, Sussex.

Mr. J. Cherry, Associate Member, has relinquished his appointment as Senior Lecturer in the Department of Economics and Production at The College of Aeronautics, Cranfield, to take up the position of Technical Manager at The Glacier Metal Company's No. 3 Factory at Kilmarnock, Scotland.

Mr. G. C. Clark, Associate Member, is now Production Manager at A. P. Newall & Company Ltd., Glasgow.

Mr. H. G. Evans, Associate Member, has taken up an appointment as Senior Lecturer in Production Engineering at the City of Bath Technical College.

Mr. G. A. Felton, Associate Member, has now left The English Electric Company Ltd., and has taken up an appointment as a Senior Engineer in the Water Turbine Department of Messrs. Boving & Company Ltd., London.

Mr. F. J. E. Pay, Associate Member, recently relinquished his position of Engineer Tech., Grade I, Tech. Costs Branch, Ministry of Supply, to take up the appointment of Assistant Chief Estimator with Davey Paxman & Co. Ltd., Colchester.

Mr. R. W. Reed, Associate Member, has now left the Royal Ordnance Factory at Poole, Dorset, to take up the position, on promotion, of Chief Draughtsman at R.A.E., Bedford.

Mr. D. G. I. Rosser, Associate Member, has now joined the staff of L. W. Bailey & Partners Ltd., Industrial Consultants, London.

Mr. R. O. Watts, Associate Member, has recently taken up an appointment as Assistant Lecturer, Grade B, at Worthing Technical College.

Mr. P. W. Bone, Graduate, is now employed by Canadair Ltd., Cartierville Airport, Montreal, as an Engineer C, working on airframe design of the CL-28 and associated aircraft.

Mr. J. Everett, Graduate, has relinquished his position as a Production Engineer with The Glacier Metal Co. Ltd., of Wembley, and has taken up an appointment with Batchelors Foods Limited, of Ashford, Kent (part of the Unilever combine), as a Production Study Engineer.

Mr. K. W. Fossey, Graduate, has now taken up an appointment as Packaging Engineer with the Minnesota Mining and Manufacturing Company, Düsseldorf, Germany.

Mr. B. G. Ghosal, Graduate, recently joined the G.K.N. Research Laboratory, Wolverhampton, as a Welding Engineer.

Mr. W. Longthorne, Graduate, left the United Kingdom recently to take up a position with Canadair Ltd., in Montreal.

Mr. J. S. Lowther, Graduate, has left the United Kingdom for Canada, where he will establish a branch of the family firm, The Notsa Engineering Company Ltd., of Aston-on-Trent, of which he is a director. His father, Mr. J. Lowther, M.I.Prod.E., is Managing Director of the Company.

Mr. E. Walker, Graduate, has left the United Kingdom to take up a position as Production Engineer with the Peruvian Southern Railway, South America, at the main works at Arequipa, Peru.

LONG SERVICE AWARDS

At a dinner given in London by the directors of Hoover Ltd., two members of the Institution who have just completed 25 years' service with the Company received long-service badges and gold watches to mark the occasion.

The members were **Mr. W. J. Dimmock,** Member, General Works Manager of Hoover Ltd., and a director of Hoover (Washing Machines) Ltd.; and **Mr. M. G. Lane,** Associate Member, Production Manager of Hoover (Washing Machines) Ltd., Merthyr Tydfil.

Mr. Dimmock is a Past Chairman of the Institution's Papers Committee, and has served on the Conference Organising Committee and on the Materials Handling Sub-Committee.

Eric Eugene Tournier, M.I.Prod.E. — An Appreciation

Eric Tournier, who passed over on 17th July last at the early age of 59 years, will be sadly missed by his many friends and the wide circle of his personal contacts in the engineering industry. He had been a member of the Institution since 1933, and his name was synonomous with the highest standards wherever tools, jigs, fixtures and the production of special prototype and high precision components were concerned.

Engineering was in his blood, his father and grandfather before him both being engineers of repute; his father built the first Maxim machine-gun in the United Kingdom. It was such an inheritance, combined with his own experience and shrewd observation, which gave him his uncanny knack of being able to estimate a job almost on sight.

One of his first engagements was with the early A.C. Car Company, where he worked under his father, who was largely responsible for the production of the first six-cylinder A.C. engine of those days and during this time he often lapped Brooklands as mechanic to that famous racing motorist, S. F. Edge.

Other early associations with the automobile industry were with Leyland's and with Windsor Cars in the early '20's. It was from the latter Company that he entered seriously into the jig and tool manufacturing side of engineering, by joining up with the two well-known brothers, George and Henry Gay, who were operating a small toolmaking business in Kingston-upon-Thames, then employing not more than a dozen hands which, under his guidance and direction, expanded to a force of some 1,200 to 1,400 employees during the peak period of the War years. During this time he was responsible for the production of many tools for well-known companies, and was intimately concerned with prototype developments of heads for the autogyro production of that time — work which later led him on to wing fixtures for the Battle of Britain Hurricane and subsequently to a large proportion of the tooling-up for the production of the Blenheim.

In early 1941, he was summoned by Lord Beaverbrook, then in charge of the Ministry of Aircraft Production, and directed to take charge of production of the Albemarle aircraft at the works of A. W. Hawksley Ltd., at Gloucester, where he remained until the completion of this work in 1943.

In 1944, he again took up his old interest in jig and tool and special component manufacture by taking over the direction of the Kingston Instrument Company, an organisation which he eventually built up to the present works at Chessington, together with a number of subsidiary companies located in Surrey and as far away as Norfolk, a pioneering development in this part of the country.

Unassuming, reserved and perhaps a little difficult to know at first, Eric Tournier was found, by the many who came to know him, to be a great and loyal friend who, with a connoisseur's knowledge of wine and food, was a generous host — a capacity in which he leaves many happy memories. L.F.M.

DIARY FOR 1958

2nd and 3rd January	**Sixth Annual Aircraft Production Conference, Southampton.** (See also Supplement to this Journal.)
6th February ...	**The 1957 Viscount Nuffield Paper,** to be presented at the University of Bristol. Speaker: **Lord Hives.** Subject: **"Technological Education".**
24th March	**The 1957 George Bray Memorial Lecture,** to be presented at the University of Leeds. Speaker: **Dr. V. E. Yarsley.** Subject: **"The Fabrication of Plastics".**
9th and 10th April ...	Conference on **"Compressed Air in Industry",** Camborne, Cornwall.
12th - 21st May ...	**Production Conference and Exhibition,** Olympia.
27th - 31st August ...	**Annual Summer School,** Ashorne Hill, Warwickshire.
29th October	**Annual Dinner of the Institution,** Dorchester Hotel, London.

Hazleton Memorial Library

REVIEWS & ADDITIONS

REVIEW

" The Specification and Management of Materials in Industry " by C. H. Starr. *London, Thames and Hudson,* 1957. XII, 194 *pages. Diagrams.* 21s.

This book serves a most useful purpose in drawing attention to a function in industry which is very often neglected. The result, as Mr. Starr indicates, is generally that an unnecessary burden is placed on the Purchasing Department in tying up the loose ends of a material specification.

The attitude of British suppliers to material specifications, and the importance of overcoming their suspicion and gaining their full co-operation is emphasised.

Attention is drawn to the considerable cost involved in production delays because a material is not being used in the manner intended. These production delays can also arise when a Purchasing Department, in all good faith, changes from one supplier to another and, in using a vague material specification, obtains materials which do satisfy all requirements. Many good examples are given to illustrate this.

One of the premises of Mr. Starr's arguments is " that expenditure in materials is usually a very large proportion of the total outlay of any manufacturing firm " (page XII). If this premise is considered, the importance of the book will quickly be recognised.

The book should be read by all managers, engineers, and those persons responsible for specifying, procuring, and controlling materials and piece parts. In applying the recommendations of the book it may be found that they do not readily fit into the many varieties of organisation in manufacturing firms, but this only indicates the need for slight adjustments, since it is obvious that one standard system of any of the modern techniques would not suit all firms. This book is a most important contribution to the improvement of manufacturing efficiency. T.A.C.S.

ADDITIONS

Abbott, W. **" Technical Drawing : A Complete Course in Three Parts."** Part I, Introductory. *London and Glasgow, Blackie,* 1957. 70 *pages. Diagrams.* 7s. 6d.

The complete course is intended to cover the syllabi prescribed by several examining bodies for the General Certificate of Education. Part I is itself a complete course suitable for pupils who do not intend to continue their studies up to G.C.E. standard, and who are entering one of the construction trades.

Abruzzi, Adam. **" Work, Workers and Work Measurement."** *New York, Columbia University Press,* 1956. 318 *pages. Diagrams.* $7.50 (60s.).

The book is in three parts: (I) Work measurement, theory, practice and fact; (II) A work measurement theory: procedure, application and results; (III) The theory of human work: beliefs, codes and observations.

In his first part the author says that: " many time study difficulties arise because the estimation function is not distinguished in any way from the evaluation function ". The establishment of production specifications is a " game " played between management and labour that can be described within the framework of the von Neumann theory of games, and in which, by the use of classical work study methods the results are often blindly favourable to one or other side. But " bargaining games over production specifications can readily be designed which are capable of yielding greater long-run advantages to both management and labour. Describing how such a game can be played is one of the primary objects of this book." The second part of the book deals with work measurement procedures. It is based in part on the author's " Work Measurement: New Principles and Procedures " (1952), but emphasis is laid on application and result rather than on technical and experimental details, for which the reader is referred to the early work. After conducting a series of experiments with stop-watch, wink-counter and marsto-chron, the author keeps the stop-watch as the measuring instrument in his new system of work measurement. It is used to measure the cycle time of operations which have previously been standardised. A predetermined number of cycles is measured, from which is calculated the mean time and standard deviation. The mean time is a measure of the level of performance, and the standard deviation a measure of consistency. The author considers in particular the problem of the job shop, and problems arising from the attitude of the workers, who, he says elsewhere in the book, are less receptive to conventional time studies, than to the sampling procedures he describes, which produce less biased results. The behaviour of workers is further considered in Part III, in which Doctor Abruzzi presents a new theory of work, including his ideas on fatigue and skill. A worker's behaviour in the workplace is the product of interacting causes both in and out of the workplace, and includes, besides a relatively stable component which can be standardised, an " occasional continually varying component, which develops in response to the work situation ". Any theory of work must therefore take into account a " non-standardised component in order to handle special situations ". In the automatic factory the two components are " sharply defined because they are physically separated ": standardised or " systematic " work is done by machines, and the " non-systematic " work which requires distinguished behaviour and distinguished skills " is reserved for humans. A highly integrated production system, such as is made necessary by automation, cannot be operated without precise and accurate information about production rates. Such information, the author claims, can be obtained by using a system such as is described in his book.

Aluminium Development Association, London. **" The Brazing of Aluminium and its Alloys."** *London, the Association,* 1957. 36 *pages. Illustrated. Diagrams.* 2s. (Information Bulletin, No. 22.)

The Bulletin describes the three main methods of brazing aluminium: flame or torch brazing; furnace brazing; and flux-dip brazing. It includes a chapter on the choice of brazing methods and another on the properties of brazed aluminium joints. The Bulletin attempts to give enough information for the reader to assess the process in relation to a particular application. " The choice of process, with its effect on joint design can influence the design of the product . . . the Bulletin is primarily addressed to product designers, production engineers and production executives . . . ."

Ashby, W. Ross. **"An Introduction to Cybernetics."** *London, Chapman and Hall,* 1956. 295 *pages. Diagrams.* 36s.
There is an impression that the study of cybernetics is inseparable from the study of electronics and higher mathematics. The author affirms that this impression is false, and that the basic ideas of cybernetics can be treated without reference to electronics and that they are fundamentally simple. Advanced techniques may be necessary for advanced applications, but much may be done by the use of simple techniques, especially in the biological sciences, from which most of the examples are taken and in which the author as cybernetician has specialised for the last 15 years. "Cybernetics" says the author "is defined by Wiener as 'the science of control and communication in the animal and the machine', in a word the art of steersmanship, and it is to this aspect that the book will be addressed. Co-ordination, regulation and control will be its themes . . . the truths of cybernetics are not conditional on their being derived from some other branch of science. Cybernetics has its own foundations. It is partly the aim of this book to display them clearly." No mathematics is used in the book beyond elementary algebra. Part I deals with the principles of mechanism, including feedback, coupling, stability, and statistical methods for analysing large and complex systems (e.g. the human brain or society). Part II uses the methods developed in Part I to show what information is, and how it is coded. It discusses mechanism and information as they are used in biological systems for regulation and control; and lays the foundation for a general theory of complex regulating systems, developing further the ideas of the author's previous book "Design for a Brain" (1952).
The book is primarily a self-instructor. It is conveniently arranged, in numbered sections, with formal definitions pin-pointed in text and index. There are sets of graded exercises.

British Productivity Council, London. **"Retailing."** *London, the Council,* 1957. 61 *pages.* 4s. (Productivity Review.)
Reviews methods and organisation in the retail trades.

British Productivity Council, London. **"Suggestion Schemes."** *London, the Council,* 1957. 10 *pages.* 1s. (B.P.C. Action Pamphlet, No. 8.)
Reviews the advantages to be gained by starting a suggestion scheme in a works, and indicates how it should be done.

Carter, Harley. **"An Introduction to the Cathode Ray Oscilloscope."** *Eindhoven, Holland, Philips Technical Library,* 1957.. (U.K. Distributors: *Cleaver-Hume, London.*) 95 *pages. Diagrams.*
This book is intended primarily for users of oscilloscopes, who may have only a slight knowledge of electronics. It could, however, be profitably read by students who want an introduction to the subject. The treatment is non-mathematical. The author describes the principles and construction of the cathode-ray tube, and of the subsidiary apparatus and circuits which together make the cathode-ray oscilloscope. He shows how to use the oscilloscope for specific applications, and gives technical information about cathode ray tubes suitable for oscilloscopes. The final chapter gives designs, circuits and specifications of several complete instruments.

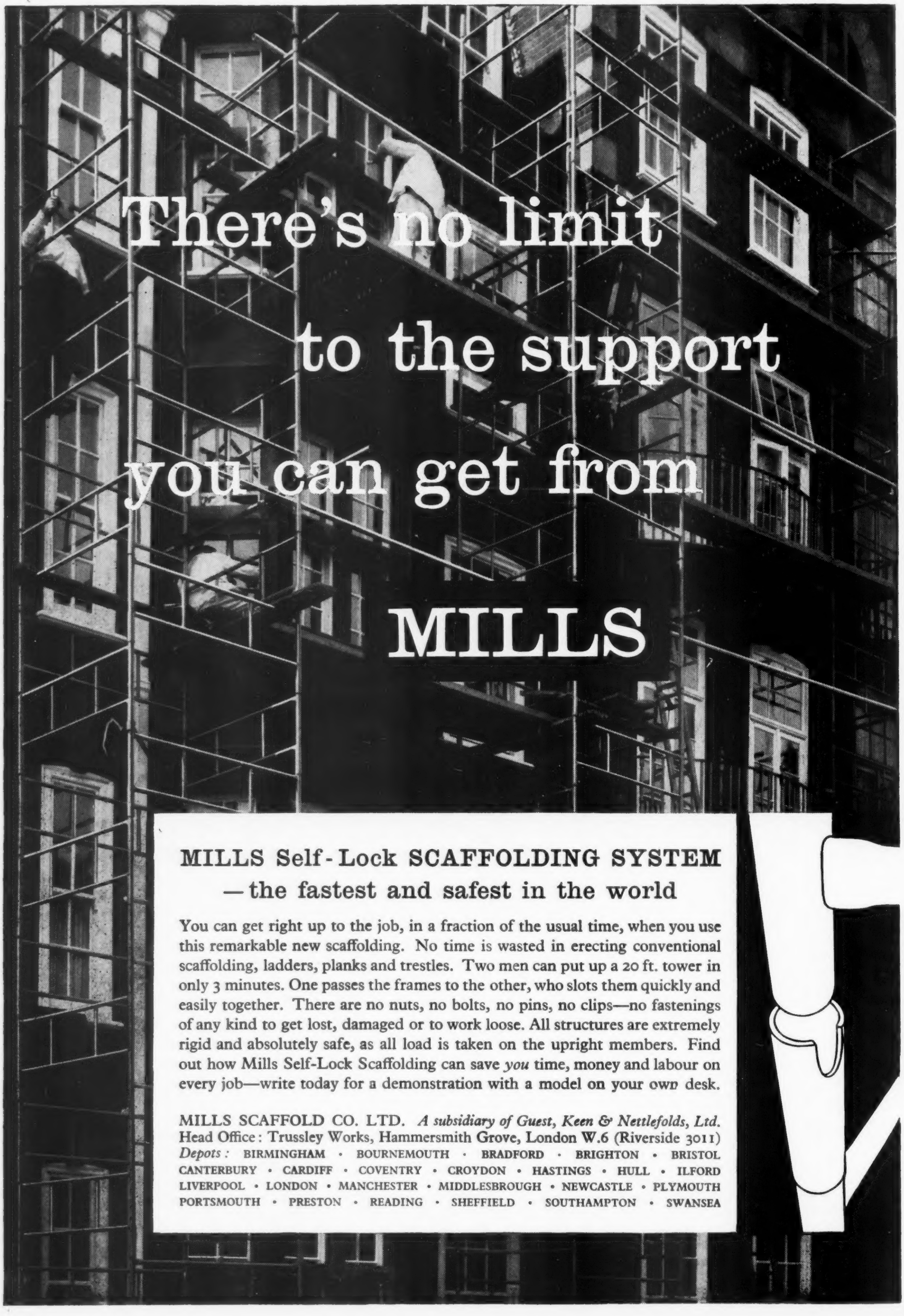
Cherry, J. **"Machinability Dynamometers at the College of Aeronautics."** *Cranfield, College of Aeronautics,* 1955 27 *pages. Illustrated. Diagrams. Typewriter script.* C.o.A Note, No. 34.)
The dynamometers described in this note were designed to provide simple robust instruments capable of being applied to large varieties of machines without modification. The note deals with the construction, calibration and uses of a lathe, and of a drill dynamometer.

Debing, Lawrence M. (editor). **"Quality Control for Plastics Engineers."** *New York, Reinhold; London, Chapman and Hall,* 1957. 142 *pages. Diagrams.* 40s.
This book is sponsored by the Society of Plastics Engineers Inc., and written by members of its Quality Control Committee. It is a textbook of statistical quality control written on the assumption that the reader has no previous knowledge of the subject. The practical examples are of applications in the plastics industry, but engineers in other industries can regard this as incidental, as the book explains in detail most of the basic principles and procedures of S.Q.C.

Institution of Mechanical Engineers, London. **"Proceedings of the Joint Conference on Combustion",** organised by the Institution of Mechanical Engineers and the American Society of Mechanical Engineers. *Boston, Massachussetts, June,* 1955 and *London, October,* 1955. *London, the Institution, n.d.* 457 *pages. Illustrated. Diagrams.*
Forty-three Papers were presented at the Conference, divided into five main headings:
1. General opening session.
2. Combustion in boilers, with special note of the development of Cyclone Firing in Germany.
3. Combustion in industrial furnaces, including advances in cupola combustion.
4. Combustion in internal combustion engines.
5. Combustion in gas turbines, with reference in particular to the types of fuel used.

Institution of Metallurgists, London. **"Behaviour of Metals at Elevated Temperatures."** Lectures delivered at the Institution of Metallurgists' Refresher Course, 1956. *London, Iliffe; New York, Philosophical Library for the Institution,* 1957. 21s.
The Institution of Metallurgists has held an annual refresher course on a selected subject since 1947. The four Papers printed here are:
1. "The Engineering Properties of Metals at High Temperatures" by Dr. N. P. Allen, Superintendent, Metallurgy Division, National Physical Laboratory.
2. "The Effect of Temperatures up to 450°C on Metals" by G. Meikle, Metallurgy Department, Ministry of Supply, Royal Aircraft Establishment, Farnborough. (Refers in particular to airframe structures and guided missiles.)
3. "Non-ferrous High-temperature Materials" by L. B. Pfeil, Director, Mond Nickel Company Ltd. (Refers in particular to what is being done to provide improved materials for high-temperature service.)
4. "High Temperature Steels" by W. E. Bardgett, Research Manager, United Steel Companies Ltd. (Shows how research is leading to a sounder basis for selecting the composition of steels for particular applications.)

MacNiece, E. H. **"Production Forecasting, Planning and Control."** 2nd edition. *New York, Wiley; London, Chapman and Hall,* 1957. 374 *pages. Illustrated. Diagrams.* $8.25 (66s.).
The first edition of this book was published in 1951. In this edition chapters have been added on automation, specialisation, standardisation and simplification; material on operational research and ration delay analysis; and a report on production engineering education and practices in Europe since the War (which is, however, too brief to be of much interest to English and other European engineers). The text includes chapter summaries, questions and discussion cases.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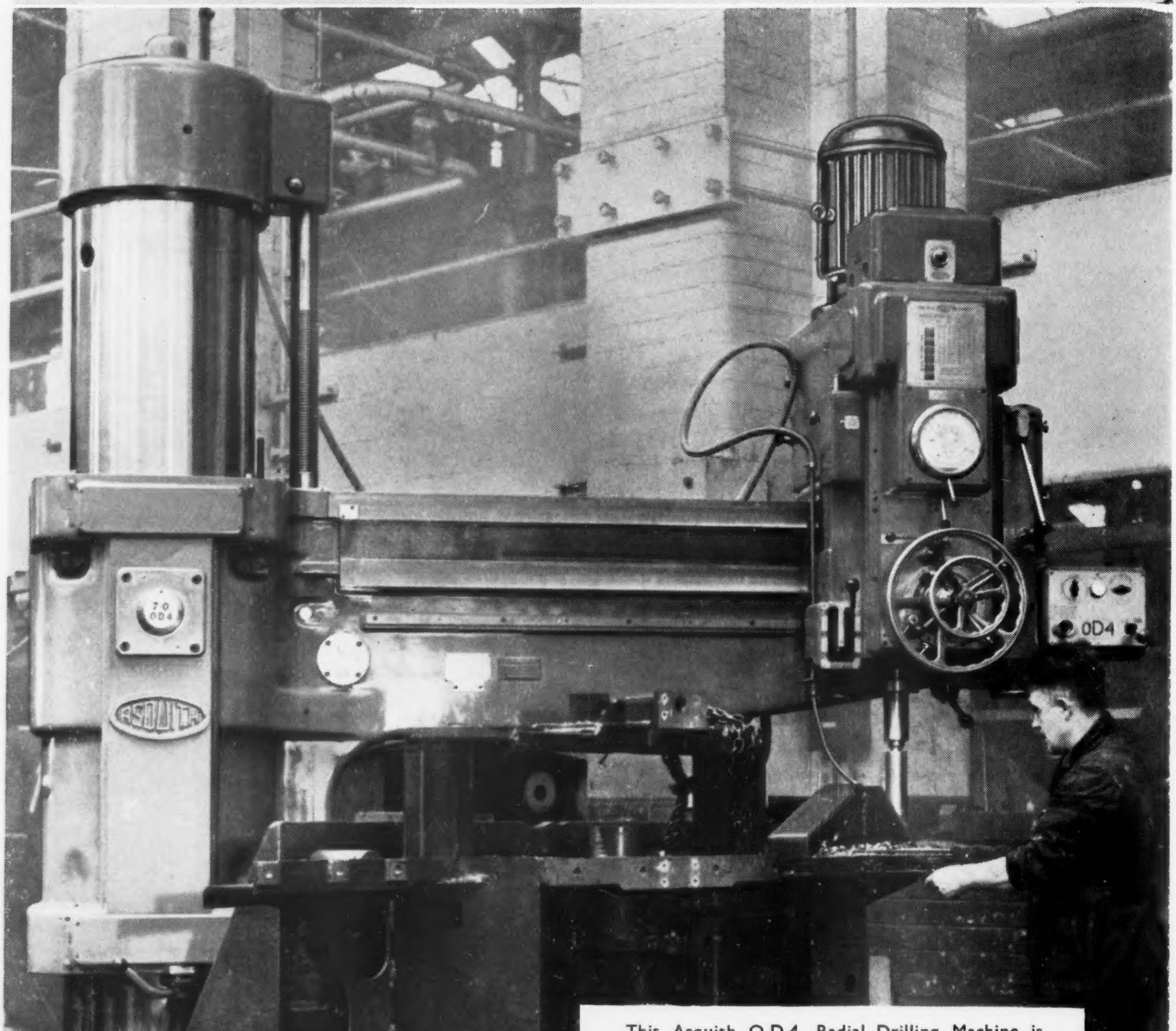
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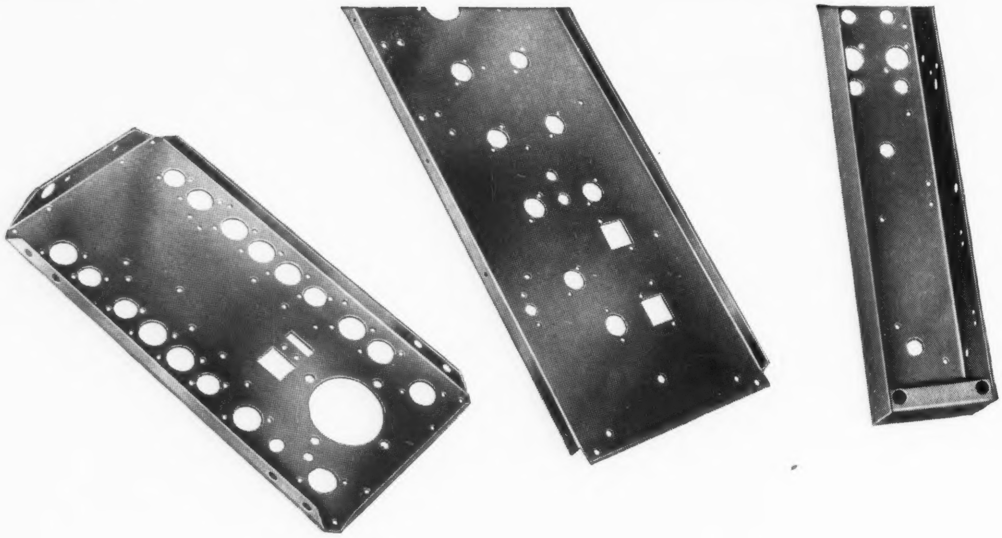

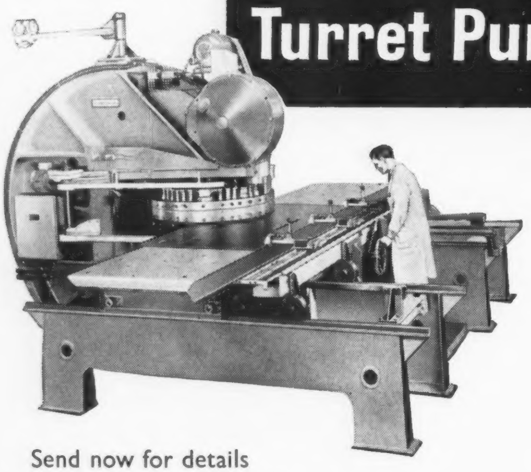

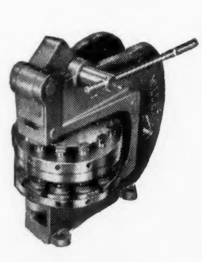

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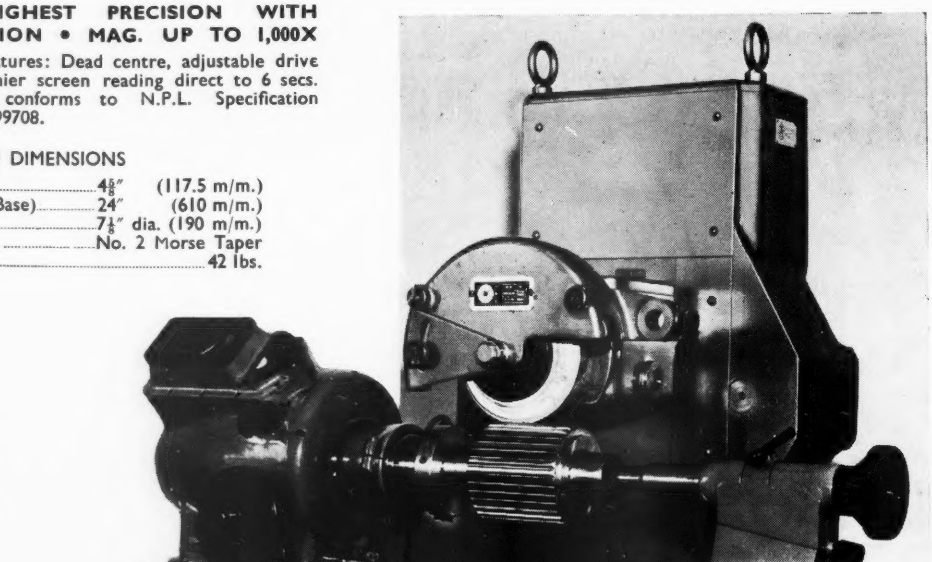

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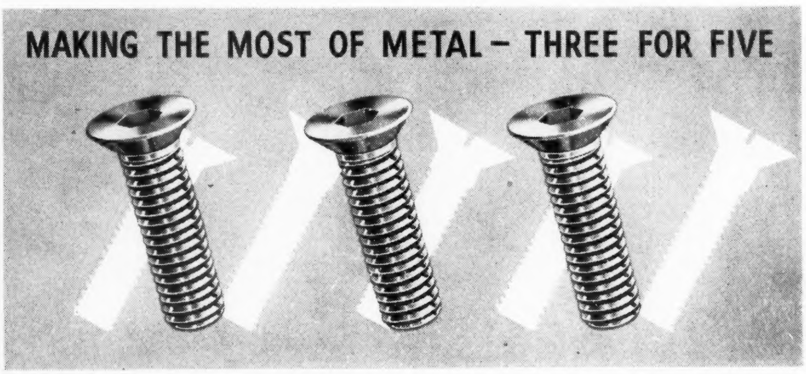

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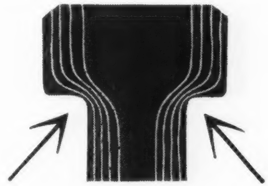
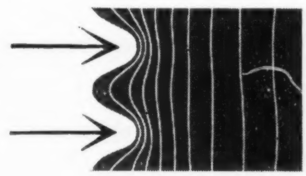


Failure due to repeated stresses on a bolt are located at the point of higher stress concentration. These points are usually the head to shank junction or the threaded section.



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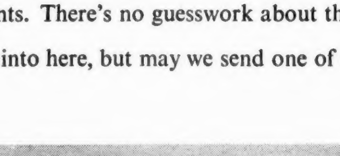

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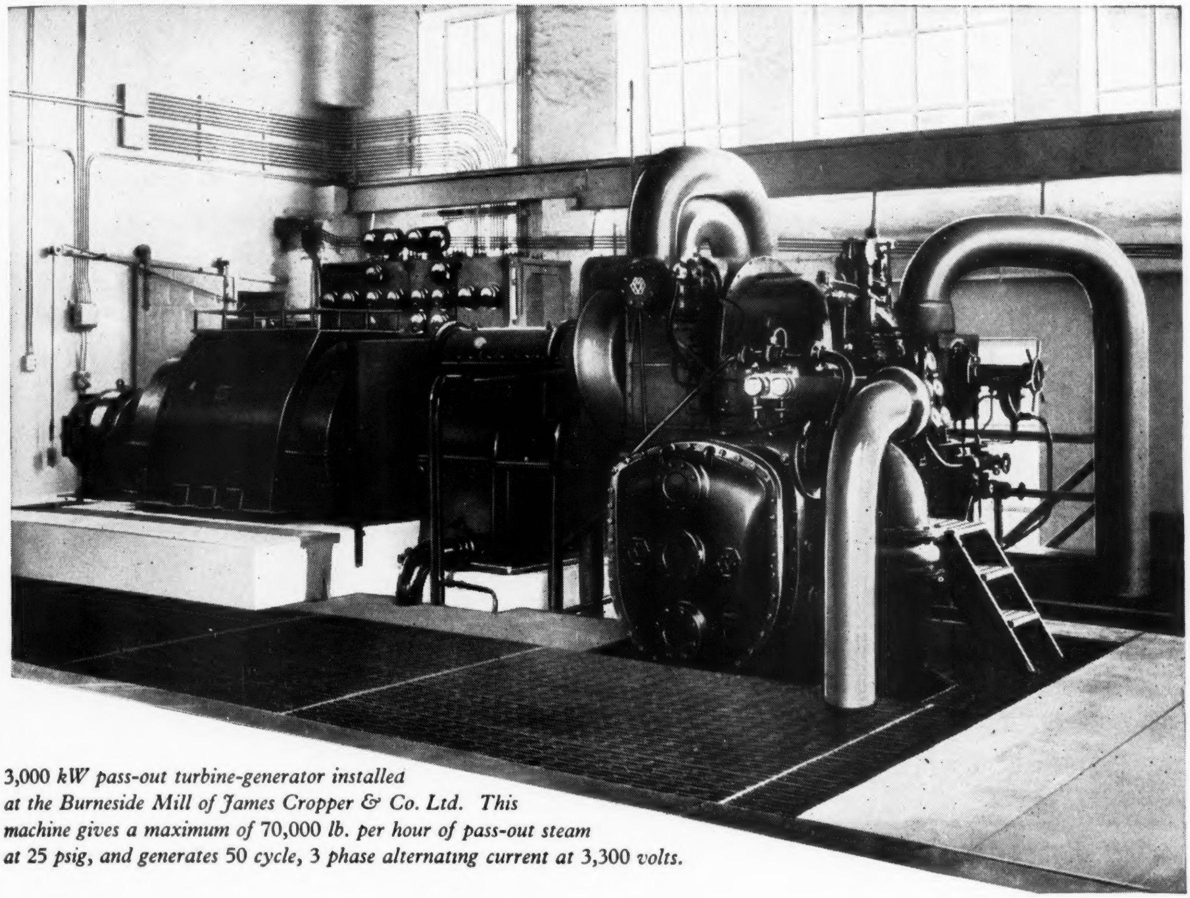

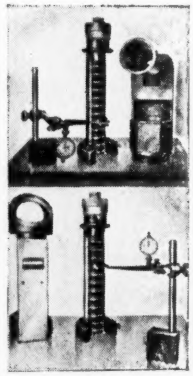

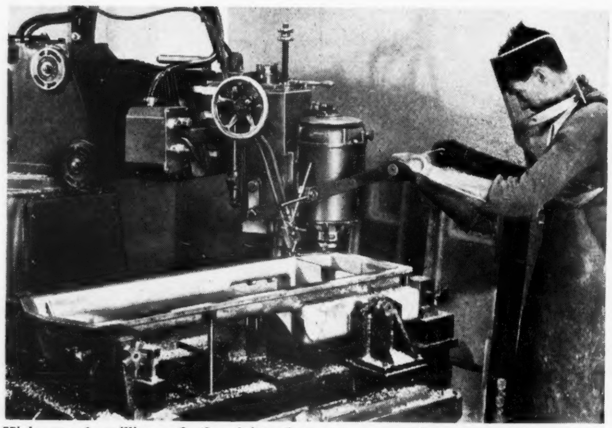

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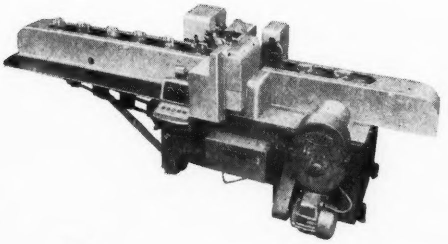

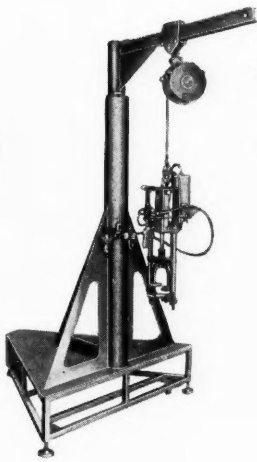

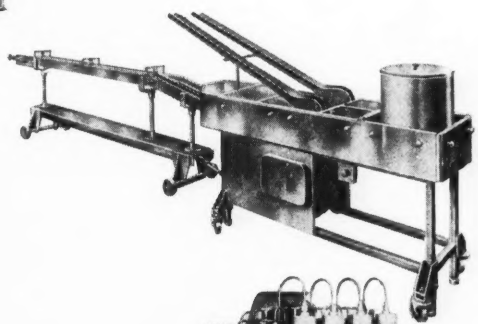

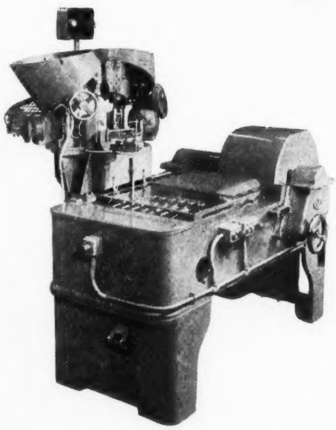

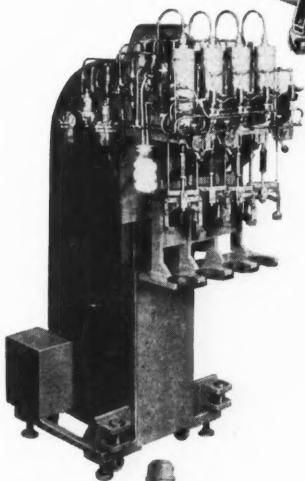

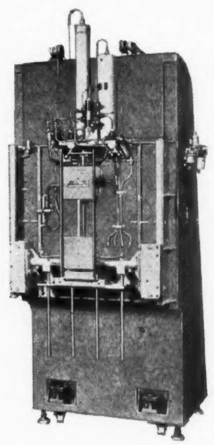

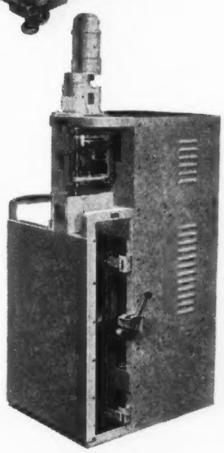

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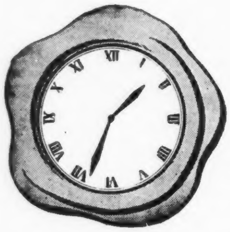

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